DOCUMENT RESUME

ED 239 077 CE 037 928

TITLE	Electrical Occupations Curriculum Guide, Levels 1 and 2. Develop and Implement Model Electrical Cluster Program.
INSTITUTION	Portland Public Schools, Oreg.
SPONS AGENCY	Oregon State Dept. of Education, Salem. Career and Vocational Education Section.
PUB DATE	Oct 83
GRANT	26-001-995
NOTE	178p.; For related documents, see CE 037 927-931.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC08 Plus Postage.
DESCRIPTORS	Behavioral Objectives; Classroom Techniques; Communication Skills; Definitions; *Electrical Occupations; *Electrical Systems; Employment Opportunities; *Equipment Maintenance; Equipment Utilization; Glossaries; Guidelines; Human Relations; Instructional Development; Instructional Materials; Intermediate Grades; Job Skills; Junior High Schools; Learning Activities; Mathematics Skills; Measurement Techniques; Program Implementation; Safety; Teaching Methods; *Trade and Industrial Education

ABSTRACT

This curriculum guide contains materials for use in implementing a two-level course in electrical occupations that is designed for students in the sixth, seventh, and eighth grades. Addressed in the course are the following topics: safety; technical communications; mathematics; tools and equipment; testing and measurement; electrical and electronic theory; assembly, maintenance, and repair; human relations; and careers. The first section of the guide includes instructions for its use, suggested teaching procedures, notes on the depth of instruction, and a glossary of terms. Provided next are concept lists and instructional planning (learning activity), exploration (instructional text and self-quiz), and project (laboratory exercise) sheets for use in each of the two levels of the course. Appended to the guide are a safety guide sheet, a project sheet, a bibliography, a circuit trainer exploration sheet, tool requirement lists, a glossary of terms, and a skills card. (MN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

OR8213202

ELECTRICITY - ELECTRONICS

ED239077

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

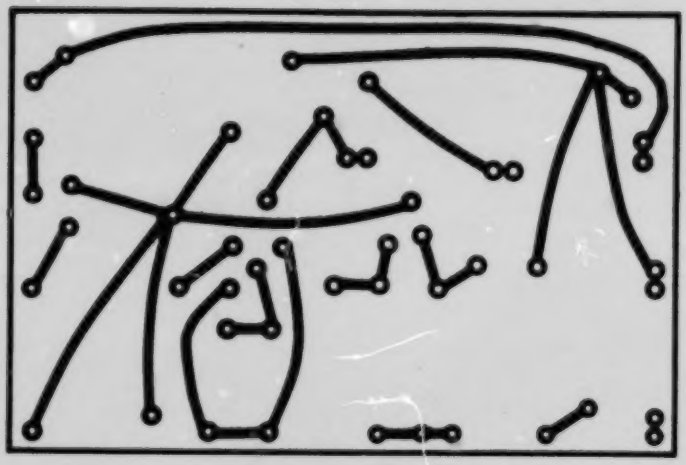
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

S. J. Case

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Electrical Occupations Curriculum Guide Levels 1 - 2



PORTLAND PUBLIC SCHOOLS

CE037928

ELECTRICAL OCCUPATIONS CURRICULUM GUIDE
LEVELS 1 and 2

DEVELOP AND IMPLEMENT MODEL
ELECTRICAL CLUSTER PROGRAM

GRANT NO. 26-001-995
VEC. NO. 20-462

PROJECT DIRECTOR: CAROL MATARAZZO

PORTLAND SCHOOL DISTRICT 1J
PORTLAND, OREGON

Dr. Matthew W. Prophet, Superintendent

Warren C. Rathbun, Supervisor
Career and Vocational/Technical Education

OCTOBER, 1983

OREGON DEPARTMENT OF EDUCATION
CAREER AND VOCATIONAL EDUCATION DIVISION

SECTION I

LEVELS 1 AND 2

SECTION I
TABLE OF CONTENTS

Introduction 1

How To Use This Course Guide 2-5

Suggested Teaching Procedures 6

Depth of Instruction; Glossary of Terms 7

Level I Concept List 8

Level I Instructional Planning Sheets (concept sheets) 9-25

Level I Exploration Sheets 26-57

Level I Projects 58-62

Level II Concept List 63

Level II Instructional Planning Sheets 64-76

Level II Exploration Sheets 77-100

Level II Projects 101-104

APPENDICES

Safety Guide Sheet 105

Project Guide Sheet 106

Bibliography 107

Exploration Sheet Circuit Trainer
(Level I & II Trainer Description) 108

Tool Requirement Lists Level I & II 109-110

Glossary of Applied Terminology. 111

Skills Card 112

Introduction

The successful program for the teaching of Electricity/ Electronics must be an articulate, well organized sequence.

The program should start at a pre high school level with an exploratory program which introduces the student to the world of electrically operated and controlled devices. The major goal, at this level, is to acquaint and motivate the student through "hands on" experiments and take home projects.

The program continues through the high school level with the instructional emphasis on the basics of electrical laws and their applications. The major goal at this level is to solidly build and establish the basic skills required by the electrical/electronics industry. With these tools it will be possible for the student to better enter the world of work and continue to specialize by attending a community college, technical school or university.

Using This Course Guide

The design of this guide makes use of instructional emphasis areas as listed in the Oregon State Curriculum Guide for Electrical Occupations:

- Safety
- Technical Communications
- Mathematics
- Tools and Equipment
- Testing and Measurements
- Electrical and Electronic Theory
- Assembly, Maintenance and Repair
- Human Relations
- Careers

CONCEPT DEVELOPMENT

From these emphasis areas an organized list of electrical and electronic concepts were developed to provide the amount of program scope required. Because of the 'high tech' characteristic of these concepts, it is necessary to introduce the ideas from these concepts on simple levels so as not to confuse or overwhelm the student. This program is organized so the same concept may appear in the beginning exploratory level and appear again at a more advanced level. The difference between the concept at the exploratory level and the advanced level would be the depth to which the concept was covered in the instruction. This brings out the fact that the needs of the advanced student require a much deeper treatment of the concept than the beginning student. The need for different depth of instruction in a single concept area has a two-fold function:

1. the need for reinforcement in the concept area
2. the need for advancement in the concept area.

The scheme used in this program guide for depth of instruction is explained on the Depth of Instruction sheet (see page).

LEVELS (concept groups)

The concepts are grouped into levels which provide a sequence for the student to follow. Each level is a planned step by step progressive experience designed to teach the basic electrical laws and at the same time motivate the student.

The electrical laws are interwoven into the student's experiences in the classroom and lab. It is suggenstd that the instructor review the Suggested Teaching Procedures sheet (page) and the Purpose of 'Hands On' Projects sheet (page).

MAJOR SECTIONS

See Program Block Analysis sheet.

This six level program is divided into 4 major sections. Each section is related to the sollowing section to provide a smooth transition for the

student.

Section 1

The discovery section. Levels 1-2 is an electronics discovery course designed for a middle school application, grades 6-8. The purpose of this course is to permote high interest and teach useable skills in the electronics area. Course length 9 weeks.

Section 2

The exploration section. Level 3 is an electrical exploration course. Level 4 is an electronic exploration course.

The electrical exploration course is designed for the beginning student that is interested in how electrical devices work. The purpose of this course is to teach how to successfully work with electrical house wiring safely, and at the same time build practical, interesting projects. It is suggested this course be 9 weeks in length, meet 2 periods per day and be used at the 9th grade level.

The electronic exploration course is designed for the student that has completed the electrical exploration course and is interested in improving his skills in the electronic field. The purpose of this course is to teach the introductory basic electronic theory and at the same time permote a higher interest environment with the construction of projects. This course is designed to be 9 weeks in length, meeting 2 class periods per day. The suggested grade level for this course is 19th grade.

Section 3

The preperation section. Level 5 instruction is for the student that completes the level 4 course and wants to continue his or her electronics training. The purpose of this course is to provide a sound working knowledge of electronic theory. It is at this level that a solid knowledge of the basic electrical fundamentals must be developed. This course should be 36 weeks in length and meet 3 periods per day.

Section 4

The specialization section. Level 6 instruction is for the student that completes the level 5 material and wants to go on with his or her electronic training for a career. This unitized instruction provides an intensive study in electronics career areas. It is at this level tha the student should develop survival skills to qualify for limited employment areas or go on to further training in technical school, college, or university. This course should be 36 weeks in length and meet 3 periods per day.

ACKNOWLEDGEMENTS

This Electricity-Electronics Curriculum Guide was prepared to supplement the revised Electrical Occupations Cluster Guide for the Oregon Department of Education. The instructional units were developed under the leadership of Carol Matarazzo, Project Director, with curriculum writing by Bill Irgens, Benson High School and George McElmury of Cleveland High School. Other Portland staff who assisted in the project include:

CLEVELAND HIGH SCHOOL

Paul Benninghoff, Principal
David Aiken, Curric. V.P.
Dave Anderson, Counselor

BENSON H.S.

David Wienecke, Principal
Aki Nishimura, Curric. V.P.
Francis Walborn, Instr.
Earl Schrader, Counselor

BEAUMONT MIDDLE SCHOOL

Paul Smith, Principal
Jan Hawkins, Counselor
Mike Baker, Ind. Ed. Instr.

HOSFORD MIDDLE SCHOOL

Thomas Marineau, Principal
Dick Boos, Ind. Ed. Instr.
Wally Serack, Ind. Ed. Instr.
Ray Snively, Counselor

SELLWOOD MIDDLE SCHOOL

Carl Piacentini, Principal
Bob Sorkin, Ind. Ed. Instr.
Carol Mooney, Counselor

VOCATIONAL VILLAGE H.S.

George Nordling, Principal
Bill Ussack, Ind. Ed. Instr.
Ellen Sweet, Instr.

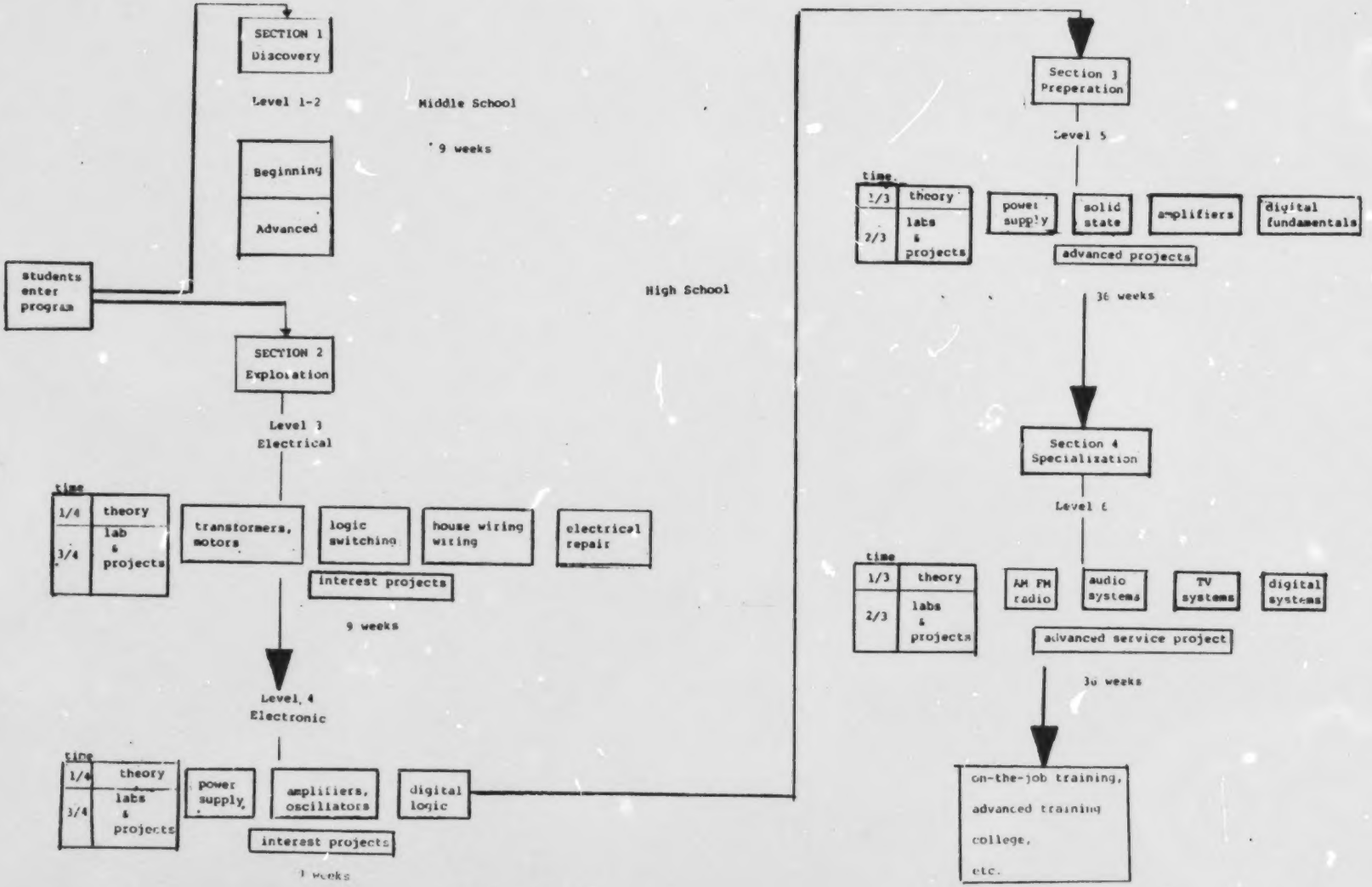
CENTRAL CAREER/VOCATIONAL/TECHNICAL EDUCATION STAFF

Warren Rathbun, Supervisor
Carol Matarazzo, Youth Employment Coordinator
Gary Tuck, Career/Vocational Education Specialist

These curriculum units will be field tested at Benson High School during the 1983-84 school year. Revision and refinement of the units will take place during the summer of 1984.

ELECTRICITY/ELECTRONICS

PROGRAM BLOCK ANALYSIS



Suggested Teaching Procedures

The use of the following procedures will give the student greater exposure to the fundamental Electrical concepts.

I. Theory Concepts

1. Objective: select/develop reasonable objective for concept presentation.
2. Organize materials: select and compile all necessary materials.
3. Present to class: present information to class by lecture, demonstration, or self-learning packages.
4. Evaluation: evaluate student performance by written examination, oral examination, or worksheets.

II. Lab Activities

1. Objective: select activity to be done.
2. Description: describe activity to students by using schematic diagrams, models, written information, etc.
3. Materials needed: distribute materials to students.
4. Procedure: distribute sequential procedure for students to follow.
5. Evaluation: student observation and operation of working model.

III. Project

1. Objective: select appropriate level project.
2. Description of project: describe project to students by using schematic diagrams, models, written information, etc.
3. Selecting and testing components: students select and test individual components before assembly.
4. Assemble project with schematic and pictorial diagrams.
5. Circuit quality visual inspection: instructor and student check project workmanship and accuracy.
6. Functional testing: (instrumental checks) student makes operational test and instrumentational tests.
7. Final project evaluation and grade: Instructor evaluates workmanship and functionability of completed project. Student explains function and operation of project to instructor.

DEPTH OF INSTRUCTION*

1 2	Introduction
3 4	Limited Working Knowledge
5 6	Working Knowledge
7 8	Advanced Working Knowledge
9 10	Design/Modification Capabilities

GLOSSARY OF TERMS

Introduction

The introductory depth of instructton includes a very basic exposure which would involve familiarization with definitions and visual identification.

Limited Working Knowledge

The limited working knowledge depth of instruction includes all of the introductory information plus basic theory with limited math relationships. The student is capable of solving problems with direction, and can assemble and analyze basic circuits.

Working Knowledge

The working knowldege depth of instruction includes all of the introductory and limited working knowledge information plus the ability to apply and use mathematical relationships to solve circuit problems. The student can assemble and test predesigned circuits and apply basic troubleshooting techniques.

Advanced Working Knowledge

The advanced working knowldege depth of instruction includes all of the introductory, limited working knowldege, and working knowledge information plus the ability to analyze existing circuits and assemblies, and make adaptations and alterations to fit special conditions. The student can work with average to complex circuits and use advanced troubleshooting techniques.

Design/Modification Capabilities

The design/modification capabilities depth of instruction includes all of the introductory, limited working knowledge, working knowledge, and advanced working knowledge information plus the ability to create using original ideas, assemble, test, and construct complex circuits.

* Depth of instruction indicates the complexity of instruction that the instructor uses in planning class presentations.

LEVEL I

Exploration Sheet List

CONCEPT LIST:

1. Sources of Electricity
2. Producing Energy from Electricity
3. Identification of Conductors and Insulators
4. Exploring the Factors of Voltage and Power
5. Exploring the Factors of Resistance and Current
6. Building Series Resistive Circuits
7. Building Parallel Resistive Circuits
8. Reading Resistor Color Code Values
9. Using the Metric Prefix System
10. Setting Up the Ohmmeter Part of the VTVM
11. Learning to Use the Range Knob and Meter Scales on the VTVM
12. Measuring Resistor Values
13. Introduction to Capacitors
14. Working With Electromagnets and Speakers (Inductors)
15. Identification of Transistor Types
16. Soldering Practice
17. The Siren Project

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Sources of Electricity

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will make electricity four different ways.

The Student Will: (using a circuit trainer)

1. Connect circuits to produce electricity by connecting a meter to:

   A. a photocell (producing electricity from light)

   B. a battery (producing electricity from chemical energy)

   C. a coil-magnet (producing electricity from magnetic energy)

   D. a thermocouple (producing electricity from heat)

   E. a crystal (producing electricity from pressure) piezoelectric effect

(The instructor may construct a model using a crystal to demonstrate the Piezzoelectric effect if desired.)

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Producing Energy From Electricity

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will convert electricity into energy 5 ways.

The Student Will: (using a circuit trainer)

1. Construct electrical circuits producing energy by using:
   - A. a motor (producing motion)
   - B. a lamp (producing light)
   - C. an LED (producing light)
   - D. a speaker (producing sound)
   - E. a resistor (producing heat)
2. Become familiar with the schematic symbols for the above components.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Identification of Conductors and Insulators

DEPTH OF INSTRUCTION

1

LEARNING ACTIVITIES

You will test the conductivity of 10 materials.

The Student Will:

1. Connect a continuity tester.
2. Test the conductivity of 10 different materials.
3. Classify each material as a conductor or insulator.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Exploring the Factors of Voltage and Power

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will connect a circuit to see how voltage affects power.

The Student Will: (using a circuit trainer)

1. Connect different nimbers of batteries across a lamp.
2. Observe the change in lamp brightness and power output.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Exploring the Factors of Resistance and Current

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will build a circuit to see how resistance affects current.

The Student Will:

1. Connect a circuit using batteries and a lamp.
2. Connect a circuit using batteries, a lamp, and a resistor.
3. Observe the effect of resistance on current flow through changes in lamp brightness and heat given off by the resistor and lamp.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Building Series Resistive Circuits

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will build 3 different types of series circuits.

The Student Will:

1. Connect a series circuit using batteries and 1 lamp.
2. Add more lamps in series with the voltage source.
3. Observe how current is affected through changes in lamp brightness.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Building Parallel Resistive Circuits

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will connect and work with parallel circuits.

The Student Will:

1. Connect a parralel circuit using 2 batteries and 2 lamps.
2. Increase the number of lamps in the circuit.
3. Alternately remove and replace bulbs in the circuit.
4. Observe the current changes (increases) when lamps are connected in parallel.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Reading Resistor Color Code Values

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will write the color code values of ten (10) resistors.

The Student Will:

1. Select ten different value resistors.
2. Attatch to Exploration Sheet.
3. Write down resistor color code values.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Using the Metric Prefix System

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will write the metric prefixes for color coded resistors.

The Student Will:

1. Read the color codes for a group of 10 high value resistors. (The same resistors used in Reading Resistor Color Code Values.)

2. Write the correct metric prefix to go with the resistor values. (This information is recorded on the same chart used in Reading Resistor Color Code Values.)

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Setting Up the Ohmmeter Part of the VTVM

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will identify the controls on a VTVM and do a basic set up procedure.

The Student Will:

1. Write the proper names of each control on a diagram of a VTVM (VOM).
2. Adjust the VTVM controls to be able to:
   A. Allow it to function as an ohmmeter.
   B. Calibrate the zero adjust and Ohms adjust to properly zero the meter.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Learning to Use the Range Know and Meter Scales on the VTVM.

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will use the Ohmmeter on the VTVM to measure the resistance of resistors.

The Student Will:

1. Adjust the Ohmmeter.
2. Test the resistance of unmarked resistors.
3. Read the meter scale.
4. Multiply the scale reading by the range to get the correct resistor value.

CONCEPT

Measuring Resistor Values

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will measure resistance values using an ohmmeter.

The Student Will:

1. Use an ohmmeter to measure the values of 10 different resistors. (These are the same resistors used in Reading Resistor Color Code Values.)
2. Record the measured resistor values on the chart.
3. Observe the similarities and differences between the color coded and measured resistance values.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Introduction to Capacitors.

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will charge and discharge an electrolytic capacitor.

The Student Will:

1. Connect a circuit with batteries and an electrolytic capacitor. Allow the capacitor to charge.

2. Disconnect the charged capacitor from the circuit and connect it to the LED-resistor component assembly. Observe the effect of the capacitor discharging through the LED.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Working With Electromagnets and Speakers (Inductors)

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will demonstrate the repulsion-attraction of a coil magnet system;

find the polarity of a speaker;

make a magnetic mortar fire game.

The Student Will:

1. Connect a circuit to demonstrate how a current carrying coil reacts to a permanent magnetic field.
2. Connect and mark a speaker as to its polarity for proper phasing.
3. Wind a solenoid to make a nail toss device.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Identification of Transistor Types

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will identify and label the leads from 4 types of transistors.

The Student Will:

1. Select and identify from an assortment of transistors
   TO-3
   TO-5
   TO-92
   TO-22
   case transistors.
2. Mark the collector, base, and emitter on each transistor using masking tape tags.

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Soldering Practice

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will make acceptable solder connections on tie strips and circuit boards.

The Student Will:

1. Study properly made solder connections from a model.
2. Watch a domonstration of proper soldering practice.
3. Review the safety practices shown in the demonstration.
4. Solder connections on circuit boards and tie strips (lug type connections).

INSTRUCTIONAL PLANNING SHEET

LEVEL I

CONCEPT

Pocket Siren Project

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will build an electronic siren that makes the same sound as an ambulance, a police car, or a fire engine.

The Student Will:

1. Identify and check off all components.
2. Identify the components by their symbols.
3. Prepare the circuit board.
4. Mount and solder the components on the circuit board.
5. Test and troubleshoot the completed circuit board.
6. Build a case for the siren.

Self Quiz - - - - - - ( )
Learning Activity- - ( )
TOTAL POINTS - - - - ( )

EXPLORATION SHEET #____
SOURCES OF ELECTRICITY

NAME_____
PERIOD_____

Exploring Concepts

1. There are many sources of energy. The two most common are: heat from burning fuels and motion from falling water.

2. Most forms of energy can be converted to electricity. Electricity is the easiest kind of energy to use.

3. Special devices must be used to change each energy source to electricity.

   These devices are:

   A) The THERMOCOUPLE.
   This changes heat directly to electricity. It produces only small amounts of electricity.

   B) ELECTRO MAGNETIC devices. (a generator or alternator)
   These make large amounts of electricity from motion. To make the electricity you must start with input-energy from:

   Steam (burning fuel or atomic reactions)

   or

   Combustion engines (turning the alternator directly)

   Hydroelectric (falling water turning the alternator directly.)

   C) The PIEZOELECTRIC EFFECT.
   This is called a crystal.
   It produces only small amounts of electricity.
   It is used in microphones and phonographs.
   It changes the mechanical energy to electricity to make the sound.

   D) SOLAR BATTERIES.
   These change light to electricity.
   Only small amounts of power have been produced so far.

   E) The CHEMICAL REACTIONS of a BATTERY can produce electricity.

-26-

Self Quiz

One point for each term.

1. To produce electricity from motion a _____ machine is used.

2. To produce electricity directly from heat we can use a _____.

3. To convery light directly into electricity we can use a _____.

4. To produce electricity by a chemical reaction, a device called a _____ is used.

INST. CHECK

Total points this section: ( )

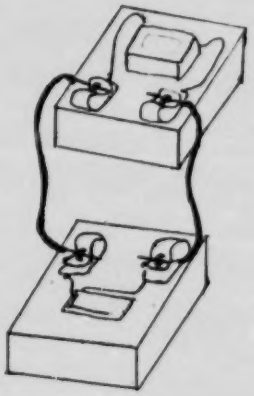
EXPLORATION SHEET #____ SOURCES OF ELECTRICITY NAME_____

Learning Activities

You will make electricity 4 different ways.

The parts kit should include:

1. a small meter
2. a thermocouple
3. a coil magnet assembly
4. a light cell
5. a battery kit



How to connect the meter to the components.

Be sure to connect positive (+) to positive and negative (-) to negative.

Tasks to do:

1. Connect the meter to the light cell. Be sure to follow the arrows because electricity has polarity (only goes one way.) Cover and uncover the cell with your hand. Shine a flashlight on the cell. The meter should move up scale as the light hits the light cell, down scale as it is covered.

Did it work? ◯ yes ◯ no

2. Connect the battery kit to the meter. Follow the diagram on the battery mount board. (Watch the polarity!) . . . . . ◯ yes ◯ no

3. Connect the meter to the coil-magnet assembly. Move the magnet in and out of the coil. . . . . ◯ yes ◯ no

4. Connect the meter to the thermocouple unit. Heat the thermocouple with a soldering iron. . . . . ◯ yes ◯ no

5. Disconnect the unit. Put the parts in the parts box.

INSTRUCTOR CHECK △

Total points this section: ☐

1) 1-6.

Self Quiz- - - - - - - 100
Learning Activity- - 100
TOTAL POINTS - - - - 100

EXPLORATION SHEET # 2

PRODUCING ENERGY FROM ELECTRICITY

NAME _____

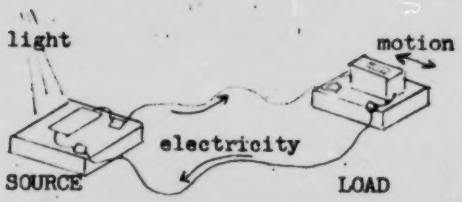
PERIOD _____

Exploring Concepts

From the last exploration sheet we learned that different kinds of energy can be converted to electricity.

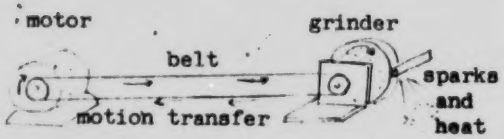
Now let's see what kinds of devices it takes to produce energy from electricity.

When we connected the light cell to the meter we were making electricity from light; then converting the electricity to motion with the meter.



Notice that there must be a complete loop for the electricity to follow. This is called a 'complete circuit'.

This electrical system is much like the mechanical system below.



SOURCE LOAD

No matter what kind of system we use, at the load end of the circuit we must connect the device that gives us the type of energy we want.

Some of these devices are:

Devices that produce light.

- Incandescent lamp
- Flourescent lamp
- LED (Light Emitting Diode)
- Electric arc
- Gas lamps (neon, xenon, mercury vapor, and sodium vapor)

Devices that produce heat

- Resistive heating elements

Devices that produce motion

- Electromagnetic devices (motors, speakers, relays, solenoids)
- Piezpelectric devices (transducers for headphones, depth finders, etc.)

Self Quiz

1. The electrical circuit must be connected in a complete _____ to operate.

2. The end of the electrical circuit that is the output (where the energy is produced) is called the _____.

3. Complete the matching exercise below.
(You will have to use the answers more than once.)

DEVICE		ENERGY TYPE
Solenoid	___	a. Heat
Crystal phone	___	b. Light
Xenon tube	___	c. Motion
Heating element	___	
Electric arc	___	
Relay	___	

INSTRUCTOR CHECK

Total points this section: 100

EXPLORATION SHEET #____ PRODUCING ENERGY FROM ELECRTICITY NAME_____

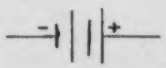
Learning Activities

You will convert electricity into energy 5 ways.

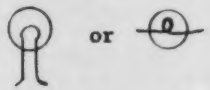
The parts kit should include:

1. a set of batteries
2. a small motor
3. an incandescent lamp
4. a red LED
5. a small resistor 4.7 ohms
6. a small speaker

These symbols will be used in the schematic drawings for the circuits you will be constructing. They are used often in all electronic drawings and work.

BATTERY 

MOTOR

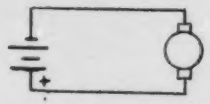
LAMP 

LED

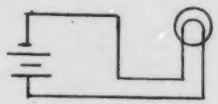
RESISTOR

SPEAKER

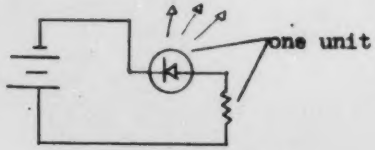
Construct these circuits.

1. 

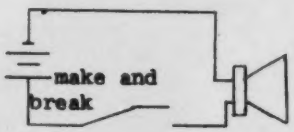
Did it work? yes no

2. 

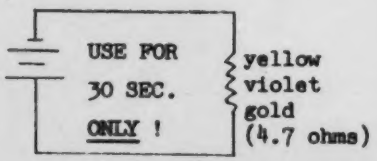
yes no

3. 

yes no

4. 

yes no

5. 

yes no

6. Disconnect unit.
Replace parts in the parts box.

INST. CHECK

Points:

Self Quiz- - - - - - 10
Learning Activity- - 10
TOTAL POINTS - - - - 20

EXPLORATION SHEET #____

IDENTIFICATION OF CONDUCTORS AND INSULATORS

NAME_____

PERIOD_____

Exploring Concepts

Now that we know about some sources of electricity and how to use electricity to produce power, we must learn how electricity transports energy. How do we move electricity?

Look around-- our world is full of wires. We see wires between poles that go to our homes and in the walls. TVs, stereos, radios, etc. are all connected inside with wires. The wires allow electricity to pass through them. They are conductors of electricity.

These are the things that determine how good a conductor is:

1. What kind of material is it? (silver is best)
2. How long is it? How far does the wire have to go? (the shorter the better)
3. How big is it around? (the bigger the better)
4. How hot will it get? (the cooler the better)

Most wires have a covering of rubber or plastic. The electricity cannot pass through the covering; it is stopped. The covering material on the wires is called insulation. The insulation lets us pick up the wires without getting shocked and keeps the wires seperated so they cannot touch each other.

So we have two classes of materials electrically-- insulators and conductors.

There are materials that are not good conductors, nor are they good insulators. Some of these are called semiconductors.

Insulators and conductors are never perfect. (We have no perfect conductor or insulator.) For most practical purposes we have common insulators and conductors that are used. The columns below list the common insulators and conductors in order (top to bottom) from the best to the not-so-good.

Conductors	Insulators
silver	glass
copper	mica
gold	waxed paper
aluminum	polystyrene (plastic)
tungsten	Teflon
zinc	air
nickel	
iron	
lead	

Self Quiz

1. _____ materials stop the flow of electricity.

2. _____ materials allow electricity to flow.

3. _____ is the best conductor of electricity.

4. Which is the better insulator, glass or air?_____.

5. The longer the extension cord the _____ it
   better / worse
   is for allowing electricity to flow.

INSTRUCTOR CHECK

Points this section: ( )

EXPLORATION SHEET #____ IDENTIFICATION OF CONDUCTORS AND INSULATORS NAME_____

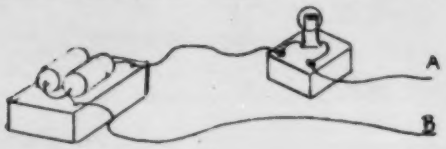
Learning Activities

You will test the conductivity of 10 materials.

The parts kit should include:

1. 2 batteries and holders
2. 1 lamp and assembly
3. conductivity test board

Construct the circuit shown below.



Test the circuit by touching leads A and B together. The lamp should light.

If a conductive material is placed across A and B, the lamp should light. This shows conductivity (continuity) of the material.

Use the continuity tester to test the continuity of each material on the conductivity test board.

Check the right column for each of the materials.

Material	Conductor	Insulator
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

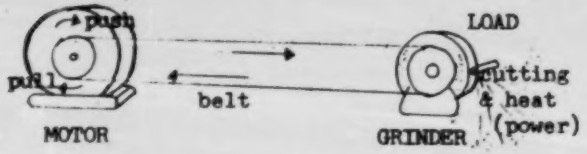
EXPLORING THE FACTORS OF VOLTAGE AND POWER

NAME_____

PERIOD_____

Exploring Concepts

To easily understand the idea of voltage and power, we can relate the idea to the grinder machine.

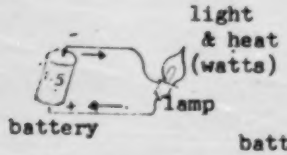


As the motor pulley turns, it pushes the belt out at the top and pulls it in at the bottom. The harder the motor pushes and pulls on the belt, the stronger (more powerful) the grinder will be. The stronger the grinder, the more grinding can be done.

The electrical circuit operates in much the same way.

The push and pull action comes from the battery.

The amount of push-pull that a battery has is called voltage. The amount of power output is called watts. The more voltage there is, the larger the watts output will be.



ONE BATTERY

1.5 volt circuit

TWO BATTERIES

1.5
+1.5
3.0 volt circuit

The batteries in the previous pictures are D Cells (the kind used in most flashlights and many other things). D Cells are 1.5 volts each. If you use more than one D Cell, the voltage is added together to give you more power.

Points to remember

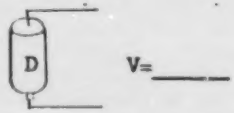
1. The greater the voltage from the battery, the brighter the lamp.
2. The power output comes from the load.
3. The power in watts is equal to the voltage times the current. (The next exploration sheet will explain current.)
4. The letter used for voltage is E or V.
5. The letter used for power is P.

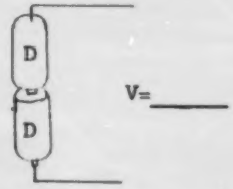
INSTRUCTOR CHECK

Total points this section:

Self Quiz

1. If the voltage is increased, the power will _____.
2. The measure of electrical push-pull is the _____.
3. The letter used to mean voltage is _____ or _____.
4. The power in watts can be found by multiplying the voltage times the _____.
5. The letter used to mean power in watts is _____.
6. What is the total voltage for each battery connection below?





EXPLORATION SHEET #____ EXPLORING THE FACTORS OF VOLTAGE AND POWER NAME_____

Learning Activities

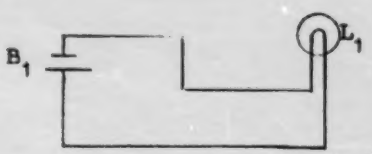
You will connect a circuit to see how voltage affects power.

The parts kit should include:

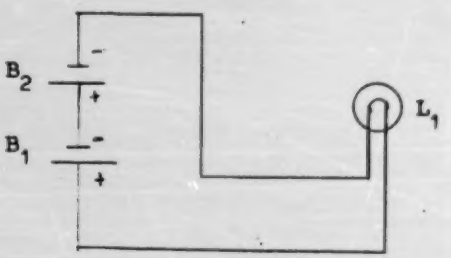
1. One lamp assembly (L_1)
2. Two battery holders
3. Two "D" cell batteries (B_1 and B_2)

Connect the circuits below and notice the brightness of the lamps.

Circuit #1



Circuit #2 (observe the polarity + and -)



Did L_1 produce more light in circuit #1 or circuit #2?_____

Which circuit had the most power output?_____

Disconnect the unit. Place the parts in the parts box.

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - - ( )
Learning Activity- - ( )
TOTAL POINTS - - - - ( )

EXPLORATION SHEET #____
EXPLORING THE FACTORS OF
RESISTANCE AND CURRENT

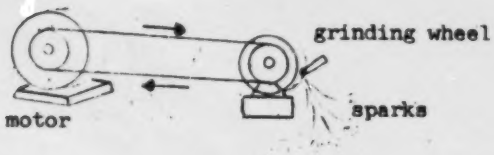
NAME_____
PERIOD_____

Exploring Concepts

From the last sheet we learned that the more voltage applied to the load, the more power we get.

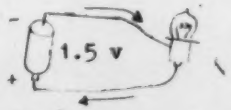
But what is it that moves the power from the battery to the load?

Let's get some more help from the grinder machine.



As you can see, the belt moves the power from the motor to the grinding wheel. As we grind, we put resistance (friction) on the grinding wheel. The resistance tries to limit how fast the belt moves.

Let's look at the electrical circuit.



Notice that it is very similar to the grinding machine. The voltage of the battery pushes little tiny particles called electrons out from the - side and pulls them in on the + side.

Just like the belt, the same amount that goes out comes back.

The electrons are so small they cannot be seen.

The flow of electrons is called <u>current</u> and is measured in <u>Amperes</u>.

As the current flows through the circuit it must go through the tiny wire inside the lamp. This is the <u>filament</u>. The filament causes electrical friction.

It is this friction that causes the light and heat power from the lamp. This electrical friction is called <u>resistance</u> and is measured in <u>Ohms</u>.

<u>Remember:</u>

1. The flow of current is called Amperes (Amps).
2. The letter I stands for Intensity of current (Amps).
3. The resestance is measured in Ohms.
4. The letter R stands for resistance in Ohms.
5. If the resistance is <u>increased</u> it will <u>reduce</u> the current.

Self Quiz

1. The measure of current flow is a unit called _____.
2. If the resistance is increased the current will _____.
3. The electrical friction is known as _____.
4. The _____ is the measure of resistance.
5. The letter R is used to mean _____.
6. The letter I is used to mean _____.

INSTRUCTOR CHECK △

Total points this section: ( )

EXPLORATION SHEET #____ EXPLORING THE FACTORS OF RESISTANCE AND CURRENT NAME_____

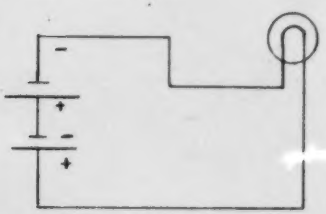
Learning Activities

You will build a circuit to see how resistance affects current.

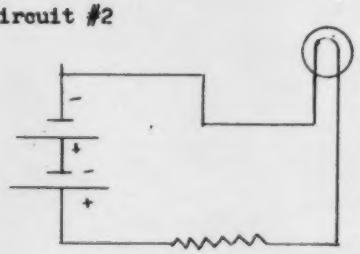
The parts kit should include:
1. 2 D batteries with holders
2. a 3.3 or ½ watt resistor
3. a Lamp and assembly

Connect the circuits below and notice the brightness of the lamp.

Circuit #1



Circuit #2



1. What happened to the brightness of the lamp?_____
2. Touch the resestor with your finger. What do you think happened to the power that was lost from the lamp?_____
3. Which circuit has the lowest current flow, #1 or #2?_____
4. Why was the current reduced?_____
5. Put the circuit parts back into the parts kit.

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - - 00
Learning Activity- - 00
TOTAL POINTS - - - - 00

EXPLORATION SHEET #____
BUILDING RESISTIVE CIRCUITS
(SERIES)

NAME_____
PERIOD_____

Exploring Concepts

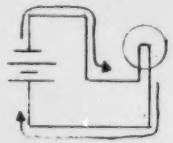
Most all electrical circuits can be broken down into 3 classifications.

They are: Series circuits
Parallel circuits
Series-parallel circuits

We will cover the series and parallel circuits only. This exploration sheet will cover the series circuit.

The series circuit

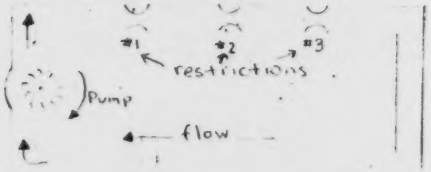
On the last sheets you have already built the series circuit. It is easy to identify because it has only one path for the electrons to flow through.



The current has only one pathway in this circuit!

The series circuit can have more than one lamp and still be a series circuit.

Here is a system that works like the series circuit. It moves fluids. Study the fluid 'work alike' circuit.



The following statements are true:

1. There is only one path for the fluid to follow.
2. The amount of fluid leaving the pump is the same as the amount coming to the pump

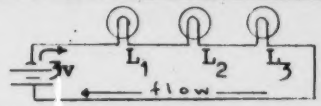
   therefore

   the flow is the same rate any place in the pipe system.
3. The more restrictions in the pipe the less the flow rate

   therefore

   the more restrictions, the more the resistance to the flow.

The series electrical circuit



The same statements are true as from the fluid circuit.

Let's review them:

1. There is only one path for the electrons to flow through the circuit.
2. The same amount of electrons leave the - side of the battery and arrive at the + side

   therefore

   the electron flow through each lamp is the same.
3. The more lamps that are added in series the less the flow will be.

   therefore

   a) The power output of the circuit will be less so the lamps will be dimmer.

   b) The total resistance of the circuit will increase the more lamps that are added.
4. If one of the lamps burns out or becomes disconnected, no current will flow and none of the lamps will light.

Self Quiz

1. What are the 3 major classes of circuit types?_____, _____, _____
2. The series circuit must have only _____ path for the electric current to follow.
3. The more lamps that are added into the circuit the more total _____ the circuit will have.
4. When more lamps are added to the series circuit the flow of current will _____.
5. In the series circuit the flow of electrons through each lamp will be _____.
6. If one lamp in the series circuit burns out, what will happen to the others?_____.

INST. CHECK △ Points: ( )

EXPLORATION SHEET #____ BUILDING RESISTIVE CIRCUITS (SERIES) NAME_____

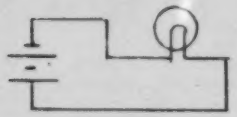
Learning Activities

You will build 3 different types of series circuits.

The parts kit should include:
1. 2 D cell batteries and holders
2. 3 lamps and assemblies

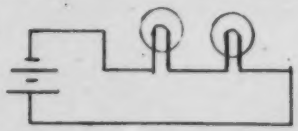
Connect these circuits:

Circuit #1



Note the brightness of the lamp

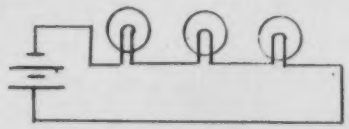
Circuit #2



Check your wiring-- Is there only one path for current?_____

Note the brightness of the lamps

Circuit #3



Check your wiring-- Is there only one path?_____

Note the lamp brightness

Return parts to parts kit.

As more lamps were added, the lamps got _____.
(brighter) (dimmer)

The total light output with all three lamps is _____ than with one lamp.
(greater) (lesser)

You can see that:

When more lamps are added in series, the circuit has more resistance. Then less current flows in the circuit and it has less power output.

INSTRUCTOR CHECK

Total points this section:( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

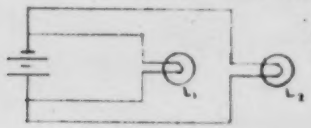
EXPLORATION SHEET #____
BUILDING RESISTIVE CIRCUITS
(PARALLEL)

NAME_____
PERIOD_____

Exploring Concepts

The parallel circuit is one of the most used and least understood circuits. So you must study this circuit carefully.

Here is an example of a parallel circuit

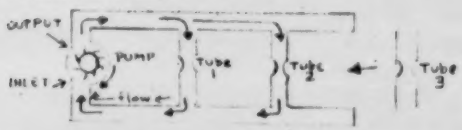


parallel circuit

This type of circuit lets each lamp work seperately. So if one burns out, the other will still operate. It is this seperate connection that makes it a parallel circuit.

The parallel circuit must have 2 or more paths for the current to pass through.

To really understand how this circuit operates, let's look at the fluid 'work alike' circuit.



The fluid that leaves the pump can go through tube 1 or tube 2 to get to the pump inlet. So there are two paths for the flow of fluid to follow.

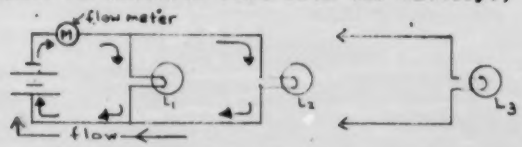
The amount of flow splits up in the top tube. Some goes down tube 1 and some down tube 2. In the bottom tube the flow from tubes 1 and 2 join together and flow to the pump inlet.

The amount of flow into and out of the pump is the same.

If we add tube 3 to the circuit, we would have 3 paths for the flow to follow. Because we have added another path, more flow can get from the top tube to the bottom tube (⅓ more). This means that the flow in the circuit with 3 paths would be more than it was with 2 paths.

So: The more paths, the less the resistance to the flow.

Let's look at the parallel electrical circuit. (We have added a flow meter to show the amount of electron flow from the battery.)



The parallel circuit works the same way:

1. The parallel circuit has 2 or more paths for current to flow through.
2. As more lamps are connected in parallel, more current will flow.
3. The more lamps that are connected, the less resistance to the flow.
4. The more current flow, the more power we can get from the lamps.
5. As more lamps are added in parallel, the flow meter will show a higher flow.

Self Quiz

1. The parallel circuit has ____ or ____ paths for the current to follow.
2. In a parallel circuit, each branch with a lamp works _____ from the lamps in the other branches.
3. The electron flow that leaves the pump is _____ as the flow that enters the pump.
4. When more parallel paths are added to a circuit, the battery must deliver more _____.
5. The total resistance of the parallel circuit _____ as more circuit paths are added.
   (increases / decreases)

INSTRUCTOR CHECK

Total points this section: ( )

EXPLORATION SHEET #___ BUILDING RESISTIVE CIRCUITS (PARALLEL) NAME_____

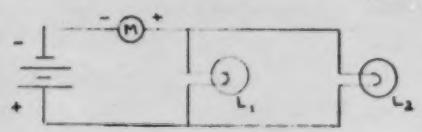
Learning Activities

You will connect and work with parallel circuits.

The parts kit should include:
1. 2 D cell batteries with holders
2. 3 lamp assemblies
3. 1 current meter

Connect these circuits as show in the circuit diagrams (schematics).

Circuit #1



Be sure to connect the battery and current meter with the correct polarity.

Be sure the lamps are connected as shown.

Do both lamps light? _____

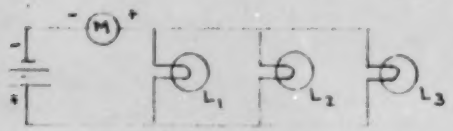
Does the current meter register up scale? _____

Note the position of the meter needle.

DO NOT DISCONNECT THE CIRCUIT.

Circuit #2

With the circuit connected as above, add L_3 into the circuit as shown in the schematic below.



You should note the following:

1. When lamp L_3 was added it had only a small effect on the brightness of lamps L_1 and L_2.
   REASON: In the parallel circuit each branch (path) operates seperately.
2. The current meter went up scale which shows increased current flow.
   REASON: When lamp L_3 was added, the battery had to produce more flow to light the lamp.
3. Temporarily remove one lamp at a time and replace it. The only lamp that goes out is the one that was removed.
   REASON: In a parallel circuit each branch operates seperately from the others. (The wiring in our homes is parallel.)

Disconnect circuit and return parts to storage. INST. CHECK △ Points: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

READING RESISTOR COLOR CODE VALUES

NAME _____

PERIOD _____

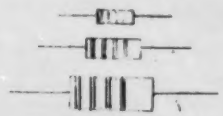
Exploring Concepts

One of the most common components that is used in electronic devices is the resistor. Because there are so many in electronic circuits, it is important to be able to recognize and determine the value of resistors.

Resistors may have several different case styles, but the most common is the color coded axial lead type.

The size of the resistor case has to do with how much heat power it can dissipate (give off) without burning up.

You will find these resistors in $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, and 1 watt sizes. Here are full size drawings for the $\frac{1}{4}$, $\frac{1}{2}$, and 1 watt sizes.



The case size (wattage) has very little to do with the resistance of the resistor. It is possible to have a $\frac{1}{4}$ or $\frac{1}{2}$ or 1 watt resistor of exactly the same resistance.

The resistance of a resistor in ohms (Ω) can be read from the colored stripes or bands around the resistor. To be able to do this you must know the color code.

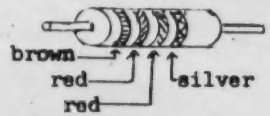
<u>The color code</u>

Each colored band on a resistor stands for a value (number). Here is a list of colors and the number each stands for.

0 Black	4 Yellow	8 Gray
1 Brown	5 Green	9 White
2 Red	6 Blue	Silver 10% (or times .01)
3 Orange	7 Violet	Gold 5% (or times .1)

To use the color code, follow the directions with the example below.

Which end has the first band we must read?



To determine the first band:

Find the silver or gold band, then count 3 bands back to the end of the resistor.

In the example: Silver - Red - Red - Brown. <u>Brown is the first band.</u>

Read starting with the band <u>nearest the end</u> of the case. There are other special cases but we will cover them as they are needed.

To determine the 'ohms' (Ω) resistance read:

1. 1st band number — Brown
2. 2nd band number — Red — 1 2 00
3. 3rd band multiplier (Number of 0's) — Red

This resistor has 1200 Ω (ohms) resistance. The 4th band is silver so this resistor could be 10% off of this value.

Self Quiz

Now that you know how to read resistor values, find the resistance of the resistors below.

You may find the omega (Ω) used for the word 'ohms'.

1. Gold, Red, Yellow, Orange — 3 00 ohms
2. Silver, Yellow, Black, Blue — 0000 ohms
3. Gold, Brown, Violet, Yellow — ohms
4. Silver, Brown, Red, Orange — ohms
5. Silver, Green, Red, Red — _____ Ω
6. Gold, Brown, Black, Brown — _____ Ω
7. Gold, Black, Black, Brown — _____ Ω

INST. CHECK Points:

EXPLORATION SHEET #____ READING RESISTOR COLOR CODE VALUES NAME_____

Learning Activities

You will write the color code values of 10 resistors.

The parts kit should include:

1. an assortment of resistors
2. Paper (form to be filled out)

Select 10 resistors. Be sure they are all different values.

Stick resistors in the first column. Use transparent tape.

Read color codes on the resistors. Write the values in the second column.

(Leave the last 2 columns blank for use with future exploration sheets.)

READING RESISTOR VALUES

	Resistors	Color Code Values	M. P.	Measured Values
	—▯—	Ω		Ω
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
			(LEAVE BLANK)	(LEAVE BLANK)

INSTRUCTOR CHECK △

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

USING THE METRIC PREFIX SYSTEM

NAME_____

PERIOD_____

Exploring Concepts

Many of the electrical values that we need to measure are very small, sometimes in the millionths. Other values are very large, as high as the millions. It is this wide range of values that makes a number 'short hand' necessary. This 'number short hand' is really a part of the metric system of measure. It is very simple once you get used to it.

Let's take a number like 1000. We say one thousand. We could shorten it by removing the 3 zeros, but, if we did we must show that they were there by adding 'Kilo'.

So 1 Kilo (1K) means one thousand. There are other prefixes besides Kilo. The ones that we will use are:

1 Mega = 1,000,000

1 Kilo = 1,000

1 milli = $\frac{1}{1000}$ (.001)

1 micro = $\frac{1}{1,000,000}$ (.000,001)

To make this system easy to use, study the chart below.

Mega	Kilo	Base Units	milli	micro
000	000	000	000	000

Let's take our number 1000 . This number is in base units. Note where base units are on the chart. To get from base to Kilo we must go 3 places to the left. Each place represents a decimal place. So: 1000.Ω. Move decimal 3 places left; add Kilo 1 KiloΩ (1KΩ)

If we want to change the 1 KiloΩ back to base units we move the decimal to the right 3 places and remove 'Kilo'.

Below are conversions which are done. Check each one using the metric conversion chart. Some are wrong. The answers are given in the Quiz section.

1. 1 Kilo = 1000 Base units
2. 1 Mega = 1,000,000 Base
3. 1 milli = .001 Base units
4. 1 micro = .000,001 Base
5. .001 Base = 1 milli
6. .01 Base = 1000 milli
7. 1000 Base = 1 Mega
8. .0001 Base = .1 milli
9. 1,000,000 Base = 1 Kilo
10. .000,01 Base = 10 micro
11. 100 milli = .1 Base
12. 5 K = 500 Base
13. 2 Mega = 200,000 Base
14. 250 K = 250,000 Base

Self Quiz

Convert the values on the left to the terms on the right.

1. 5 Kilo _____Base
2. 1000 K _____Mega
3. 1000 micro _____milli
4. 100 milli _____Base
5. 250 milli _____Base
6. .0001 milli _____micro
7. 500 Kilo _____Base
8. 100 micro _____milli
9. 1 Mega _____Kilo
10. .01 milli _____Base

INSTRUCTOR CHECK

Total points this section:

wrong answers for list: 6, 7, 9, 12, 13

EXPLORATION SHEET #____ USING THE METRIC PREFIX SYSTEM NAME_____

Learning Activities

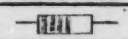
You will write the metric prefixes for color coded resistors.

Return to the Exploration Sheet from Reading Resistor Color Code Values.

Fill in the column marked M. P. (metric prefix) on the chart for Reading Color Code Resistor Values.

If the 3rd band IS orange, yellow, or green fill in the M.P. column.
If it is NOT orange. yellow, or green, then leave it blank.

READING RESISTOR VALUES

	Resistors	Color Code Values	M. P.	Measured Values
		Ω		Ω
1.				
2.			Fill in ONLY if the 3rd band is orange, yellow, or green.	
3.				

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - - ( )
Learning Activity- - ( )
TOTAL POINTS - - - - ( )

EXPLORATION SHEET #____
SETTING UP THE OHMMETER
PART OF THE VTVM

NAME_____
PERIOD_____

Exploring Concepts and Learning Activities

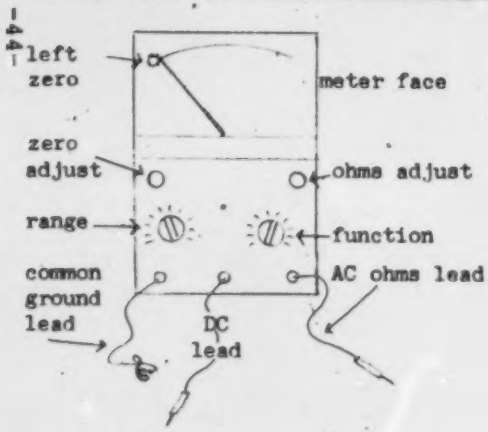
Check out a VTVM meter

The color code tells us what value the resistor should be. However we cannot see into a resistor. If the resistance changes we would not be able to know unless we could measure it.

The device used to measure ohms is called an ohmmeter.

The ohmmeter we will use is part of a multimeter. The multimeter we will use is called a VTVM. The VTVM will measure AC voltage, DC voltage, and Ohms. We will now learn to set up the VTVM to take ohms measurements.

Recognizing the parts of the WV-77E volt Ohmyst



Setting up the VTVM to measure resistance

1. Plug unit into 110 v. AC main.
2. Turn function switch to DC+.
3. After the needle stabilizes, turn the zero adjust so the needle rests on the left zero.
4. Turn the function switch to the ohms position. (Be sure the test leads are not touching together.) The needle should swing up scale.
5. Turn the ohms adjust so the needle is on the last line of the top scale. (Just after the 1000).
6. Touch together the probe ends of the test leads that come out of the meter. One is marked ground and one is marked AC ohms.
7. The needle should swing back to the left zero. (If it is not exact, you can touch it up with the zero adjust knob.)
8. Take the leads apart. (Don't touch the probe ends with your hands as this could cause incorrect readings.)
9. Check to be sure the needle is on the last line on the right (as in step 5). Touch up the setting with the ohms adjust knob.

This completes the standard set up proceedure.

This must be done each time before you can use this meter.

Check the VTVM meter back in.

INSTRUCTOR CHECK ( )

Total points this section: ( )

EXPLORATION SHEET #____ SETTING UP THE OHMMETER PART OF THE VTVM NAME_____

Self Quiz

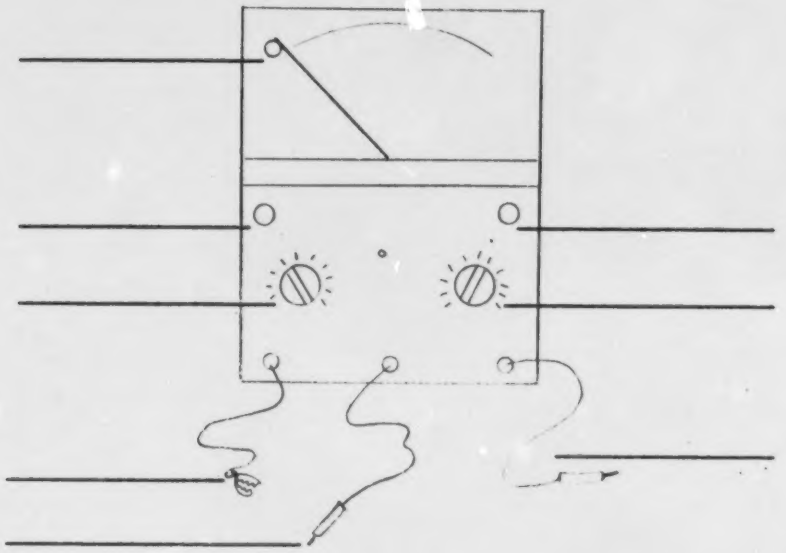
1. The VTVM will measure AC volts, DC volts, and _____.

2. Each time that the range kno- is changed, you must check the

_____.

3. The ohms scale on the meter is _____ on the top end.

Lable the parts of this VTVM.



70

71

INSTRUCTOR CHECK

Total points this section:

Self Quiz- - - - - - ( )
Learning Activity- - ( )
TOTAL POINTS - - - - ( )

EXPLORATION SHEET #____

LEARNING TO USE THE RANGE KNOB AND METER SCALES ON THE VTVM

NAME_____

PERIOD_____

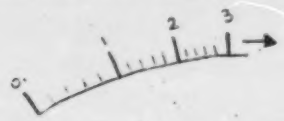
Exploring Concepts

Check out a VTVM and a resistor block.

The scale that is used to measure resistance (ohms) is the top scale on the meter.

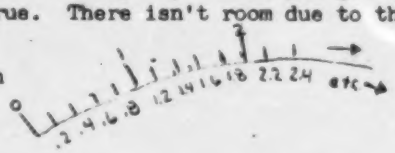
Notice that this scale is compressed as you go up scale. (The numbers are closer together on the top section.) For this reason you should try to do your readings on the lower 2/3 of the scale.

Let's take a look at how this scale is read.



The lower part of the scale is divided into 5 spaces between each number 0 to 1 and 1 to 2, etc. When you get above 7 this is no longer true. There isn't room due to the scale compression.

When there are 5 spaces between each number, each line is worth .2 :



So:

The needle reads 2.4 .
The highest that can be read on the VTVM meter scale is 1000, (the top number).

The range switch

To be able to read above the range of the scale, we use an expansion system. Look at the range switch. We will use only the Rx1, Rx10, and similar numbers.

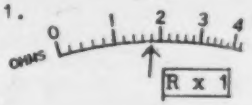
In this position (Rx1) each number reads directly from the scale. If the meter needle were on 10, we would multiply by 1. This means the reading is 10 ohms.

In this position (Rx100) each number read from the scale must be multiplied by 100. If the needle were on 2.4, we would multiply this by 100 which is 240Ω.

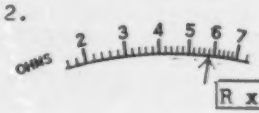
When using the range switch it is important that you check the 0 and ohms adjustment EACH TIME that you change positions!

Self Quiz

Read these scales:

1. 

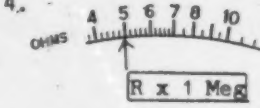
_____

2. 

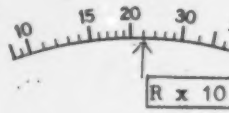
_____

3.

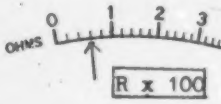
_____

4. 

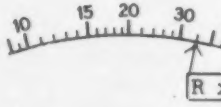
_____

5. 

_____

6. 

_____

7. 

_____

8.

_____

INST. CHECK ( ) Points: ( )

EXPLORATION SHEET #____ LEARNING TO USE THE RANGE KNOB AND METER SCALES ON THE VTVM NAME_____

Learning Activities

You will use the ohmmeter on the VTVM to measure the resistance of resistors.

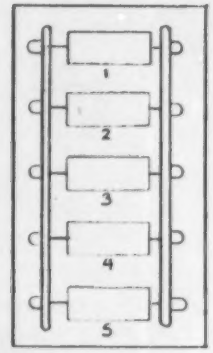
You will use: the VTVM and the resistor block

Now you are ready to take resistance measurements. Look at the resistor block. You cannot see the color code on most or all of the resistors. You will have to figure out their resistances using meter readings rather than the color code.

Don't forget to check the 0 before each measurement.

Proceedure:

1. Place the ohms test prod on one end of resistor #3 and the ground lead on the other end of the same resistor.
2. Change the range knob to a position that puts the needle in the lower 2/3 of the scale.
3. Remove the test leads from the resistor and check the 0 and ohms scale set up.
4. Note the range (R x 1000 or R x 10 K).
5. Read the meter scale. The needle should be near 1 (R x 10 K range) or 10 (R x 1000 range).
6. Multiply the range times the scale reading and fill in this value on the #3 blank.



Resistor Block

Measure each resistor with the ohmmeter and write each value below.

1._____ 4._____

2._____ 5._____

3._____

Check in the VTVM and the resistor block.

INSTRUCTOR CHECK_____ Total points this section:_____

resistor values: 1)10Ω, 2)100 Ω, 3)10,000 Ω, 4)1 MegΩ, 5)470 KΩ.

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

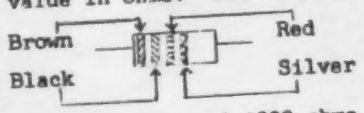
EXPLORATION SHEET #____
MEASURING RESISTOR VALUES

NAME_____
PERIOD_____

Exploring Concepts

Now that you know how to set up the ohmmeter, we are ready to test resistors.

From exploration sheet #8 we know that the first 3 bands on the resistor tell us the value in ohms. The resistor below is a 1 KΩ resistor.



The ohmmeter should read 1000 ohms for a good resistor.

But this is not always the case. Some resistors will read right on the mark, but most will not. To start with, the resistors are not perfect. The 4th band tells us how good the resistor should be or how far off it may be. This possible amount of variation is called tolerance.

The 1 KΩ resistor above has a silver 4th band. This means the resistor could be off value as much as 10% on either side of 1000Ω. The reading could be as low as 900Ω or as high as 1100Ω and still be a good resistor.

To make matters worse, the ohmmeter is not perfect. The ohmmeter can have 1% - 4% error and that's a good ohmmeter! So it is possible for the ohmmeter to read right on the mark and the resistor still be off color code value. This may happen if the error of the resistor is up and the error of the meter is down.

Let's review the tolerance system: silver - 10%
gold - 5%

Examples of tolerance value:

resistor	tolerance spread
10 Ω 10%	9 - 11 Ω
100 Ω 10%	90 - 100 Ω
1000 Ω 10%	900 - 1100 Ω

As you can see from the above values, the more ohms a resistor has the more ohms error it can have.

As you take resistance measurements you must take into account the amount of error possible for each resistor.

Self Quiz

1. Tolerance value on resistors shows the amount of _____ in resistance.

2. The 4th band on the resistor is called the _____ band.

3. The color gold is used to mean _____% tolerance.

4. The color silver is used to mean _____% tolerance.

5. The amount of error that can be expected from an ohmmeter can range from _____ to _____.

INSTRUCTOR CHECK

Total points this section: ( )

EXPLORATION SHEET #____ MEASURING RESISTOR VALUES NAME_____

Learning Activities

You will measure resistance values using an ohmmeter.

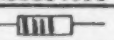
You will need:

VTVM

Resistor sheet from exploration sheet #8 (Reading Resistor Color Code Values)

Using the ohmmeter, measure each resistor on your sheet and write in the values under the heading 'Measured Value'.

READING RESISTOR VALUES

	Resistors	Color Code Values	M. P.	Measured Values
		Ω		Ω
1.				
2.				Measure the resistors and fill the values in this column.
3.				
4.				

INSTRUCTOR CHECK

Total points this section:

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

INTRODUCTION TO CAPACITORS

NAME_____

PERIOD_____

Exploring Concepts

Next to resistors, the most common component in electornic circuits is the capacitor.

There are many types of capacitors, but they all operate in the same way:

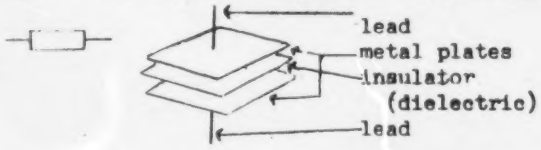
Capacitors charge and store electrical energy.

It is because of this, that capacitors are used for: filters in power supplies, tuning circuits in radios and TVs, speaker cross-over systems, and others.

Capacitors can block the flow of direct current but will allow the effects of alternating current to pass through themselves and the circuit.

-50-

Let's see how a capacitor is constructed. Here is an exploded diagram of a capacitor:



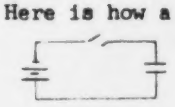
There are 2 metal plates seperated by an insulator (dielectric) inside a capacitor. The top and bottom plate do not electrically touch each other but, because the insulator between the plates is very thin, they are very close together. The distances between the plates can be less than a thousandth of an inch. It is this closeness of the plates that makes the capacitor work. The capacitor plates and dielectric are normally rolled up to make the unit more practical to use.

Capacitors are classified by the type of dielectric they use. A paper capacitor uses a paper dielectric, a mylar capacitor uses a plastic sheet for the dielectric, etc. There are many types of dielectrics used in capacitors.

The symbol that is used for capacitors is shown below:

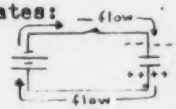
Notice the similarity between the symbol and the actual construction of a capacitor.

Here is how a capacitor operates:



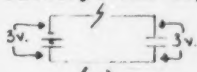
(a)

when the circuit is connected



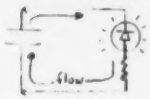
(b)

In circuit (b) the flow of electrons is building a charge on the capacitor. (Electrons build up on the top plate and are removed from the bottom plate.) This action continues until the charge across the capacitor equals the voltage of the battery. The capacitor is 'charged'.



(c)

In drawing (c) the capacitor will stay charged until it is discharged by connecting it into a circuit.



(d)

In drawing (d) the LED will light and remain on until the capacitor is discharged.

Capacitor size is measured in μfd (Microfarads). This is the measure of capacitance.

Self Quiz

1. The capacitor is made up of two metal plates with a _____ between them

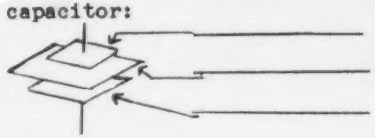
2. When the capacitor is connected to a battery it will _____.

3. The type of capacitor is classified by its _____.

4. Capacitors will block _____ current.

5. Capacitors will allow _____ current to pass.

6. Name the parts of this capacitor:



7. The capacitor size is measured in _____.

INSTRUCTOR CHECK

Total points this section: ( )

EXPLORATION SHEET #____ INTRODUCTION TO CAPACITORS NAME_____

Learning Activities

You will charge and discharge an electrolytic capacitor.

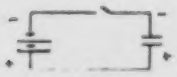
You will use a 1000 μfd capacitor in the activity. The 1000 μfd capacitor is classified as a very large capacitor electrically.

The parts kit should include:

1. 2 batteries and holders
2. LED
3. 1000 μfd capacitor

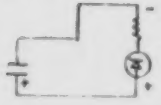
Connect the circuit below:

be sure to observe polarity!



Complete the circuit to allow the capacitor to charge.

Remove the capacitor from the circuit and connect it to the LED.



Notice the light from the LED. How long does it stay on? _____(approximately)

Repeat the proceedure several times.

Return the parts to storage.

INSTRUCTOR CHECK △

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____
WORKING WITH ELECTROMAGNETS AND SPEAKERS (INDUCTORS)

NAME_____
PERIOD_____

Exploring Concepts

Another device found in electric and electronic circuits is the inductor. Most inductors are easy to recognize because they have coils of wire.

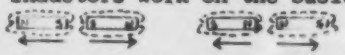
There are many different kinds of inductors. Some are very common and are seen every day. Others are very special and are found only inside high technology equipment.

Here is a list of inductors. How many can you recognize?

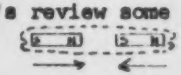
___chokes	___solenoids	___variac	___tape heads	___ballast
___speakers	___delay lines	___relay	___microphones	
___motors	___transformers	___motor starter	___saturable reactors	

7 is a very good score

All inductors work on the basic magnetic laws. Let's review some of them:



Like magnetic poles repel.



Unlike magnetic poles attract.

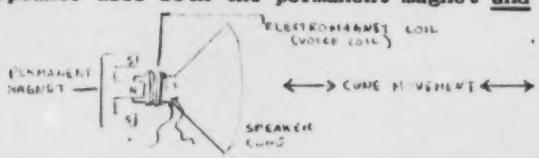
There are two kinds of magnets: permanent magnets and electromagnets. These laws of attraction and repulsion apply to both kinds.

The permanent magnet cannot be turned off and we cannot change the amount of pull it has. It is used in speakers and some motors.

The electromagnet is more useful because it can be easily controlled. It is made of a series of coils of wire.

It was discovered that any wire with a current flowing through it has a magnetic field around it. The coil is a way to get more wire into a small space to increase the magnetic effect. It is the force field around the magnet that makes it work.

The speaker uses both the permanent magnet and the electromagnet.



It is the repulsion and attraction between the two magnetic systems that pushes the cone out and pulls it inward.

Self Quiz

1. Like magnetic poles _____.

2. Unlike magnetic poles _____.

3. A _____ type magnet cannot be turned off or on.

4. All wires that have current flowing through them have _____ around them.

5. The coil is a way to _____ the magnetic field present around all wires that have electricity going through them.

INSTRUCTOR CHECK

Total points this section: ( )

EXPLORATION SHEET #____ WORKING WITH ELECTROMAGNETS AND SPEAKERS (INDUCTORS) NAME_____

Learning Activities

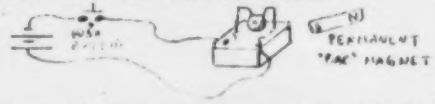
You will demonstrate the repulsion-attraction of a coil magnet system; find the polarity of a speaker; make a magnetic mortar fire game.

The parts kit should include:

1. battery set and holders
2. one push button
3. one speaker
4. one mortar fire tube assembly with coil form and nails for ammunition
5. wire for coil (200 turns)
6. one bar magnet
7. one coil swing unit

Activity #1: Repulsion-attraction of an electromagnet

Connect this circuit as shown.



Push the button and bring the magnet near the coil.

What happened? _____

Push the button and bring the other end of the magnet near the same side of the coil. What happened?

_____

Reverse the wires on the battery and repeat the whole experiment. What happened? _____

INSTRUCTOR CHECK

Activity #2: Polarity of a speaker

Connect this circuit as shown.

Watch the speaker cone and push the button momentarily. Does the cone move out or in? _____

Reverse the battery connections.

Watch the speaker cone again and push the button momentarily. Does the cone move out or in? _____

Speakers should have a red dot on one terminal. With the positive side of the battery connected to the red dot the cone should move outward.

INSTRUCTOR CHECK

Activity #3: Making an electromagnetic mortar fire game

Wind 200 turns of #22 wire around the glass tube. Don't criss cross as you go around. Be sure to wind the wire neatly. Leave 5" leads on each end of the coil.

Wrap tape around the wire so it won't unwind.

Strip ½" of insulation off of each lead for connecting.

Check out a high current power supply. Connect the circuit as shown.

Adjust the power supply for approximately 15-20 volts output.

Drop a nail into the top of the tube.

> **DANGER:** Do NOT look down into the tube or let it point at anyone!

Hit the button quickly on and off.

Did the nail pop out of the tube? Keep trying.

How high can you get the nail to go?

You have built a solenoid sucking coil

Put away all materials.

INSTRUCTOR CHECK Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

IDENTIFICATION OF TRANSISTOR TYPES

NAME_____

PERIOD_____

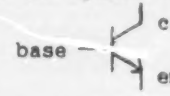
Exploring Concepts

Transistors play a very important part in electronic circutry. It is these devices that amplify. They may be found singly or by the hundreds inside an integrated circuit. We will start our study of transistors one at a time.

What do they look like?

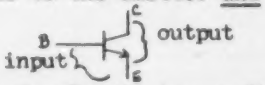
Just like most electronic devices, there are different types. We will cover the ones you will see in the projects.

The symbol for a transistor is the same no matter what case it is in. This drawing shows the symbol for a transistor.



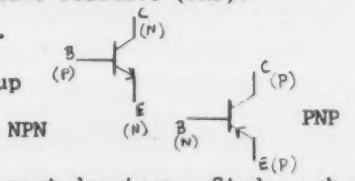
The transistor has 3 leads, the: base (B)
emitter (E)
collector (C)

In most circuits, the input of the transistor connects to the base and emitter. The output connects to the emitter and collector. This is called a 'common emitter'.

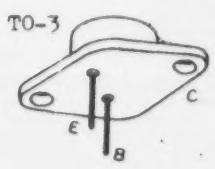


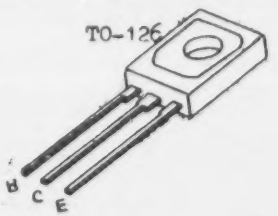
The transistor has 2 polarity types: Negative Positive Negative (NPN) and Positive Negative Positive (PNP).

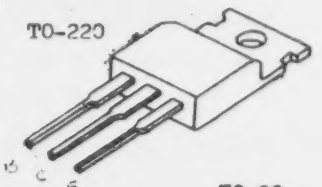
The following drawings show the two polarity types. You cannot tell which is which by looking at them. To identify the type, you must test it or look it up by the type number.



The case styles of the transistor are shown in the next drawings. Study each of them. You will see some of them in your projects.







Self Quiz

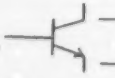
1. The transistor has _____ number of connections.

2. The transistor is found in two polarities. They are _____ and _____.

3. This symbol is for a _____ transistor.

4. This symbol is for a _____ transistor.

5. Name the connections (leads) on the transistor below:

_____  _____
_____

INSTRUCTOR CHECK

Total points this section: ( )

EXPLORATION SHEET #____ IDENTIFICATION OF TRANSISTOR TYPES NAME_____

Learning Activities

You will identify and label the leads from 4 types of transistors.

The parts kit should include:

1. An assortment of different case transistors
2. Masking tape to make tags from

Select a:

TO-3

TO-5

TO-92

TO-220

Make 16 tags:

4 - marked C

4 - marked E

4 - marked B

Place the tags on the correct leads from each transistor.

Have your teacher check to see if you are correct.

Remove all tags and place the parts back in the parts kit.

INSTRUCTOR CHECK △

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

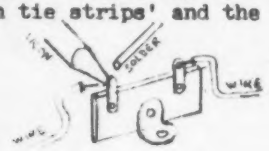
EXPLORATION SHEET #____
SOLDERING PRACTICE

NAME_____
PERIOD_____

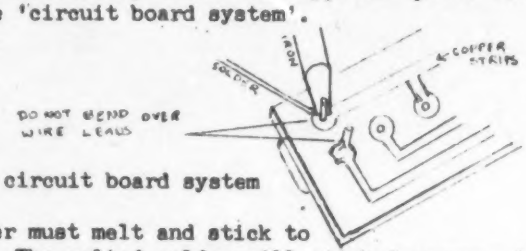
Exploring Concepts

Electricity can only flow through a connected (closed) circuit. The most common method of making electrical connections that are reliable, so electricity can pass through the circuit, is soldering.

There are two types of soldering connection systems. One type is 'point to point wiring on tie strips' and the other is the 'circuit board system'.



tie strip



circuit board system

For these systems to work the sloder must melt and stick to the wire and the connector stripe. The melted solder will stick to copper like water will wet a surface. If the solder cannot wet the surface it will roll off just like water on an oily surface. The surface must be clean so the solder will wet and stick to the wire and connector. To keep the surface clean a flux is added to the solder. Rosin is used in most solder for a flux.

60/40 solder melts at about 400°F so the soldering iron must be slightly hotter to be able to heat the connection and melt the solder. We must be very careful not to burn ourselves with the hot iron or melted solder. When you are not soldering keep the iron in the stand. Remember: When not in the hand it is in the stand.

The eyes must be protected when you are soldering. Safety goggles or glasses must be worn.

Hold the iron by the handle and hold hot wires with a pair of needle nose pliers.

The soldering proceedure

1. The iron must be clean and tinned.
   a. Heat the iron to temperature.
   b. Wipe the tip with a wet sponge or paper towel.
   c. Put a drop of solder on the iron to form a small puddle.
2. The connection must be clean.
   a. Strip wire the correct amount (1/8 ").
   b. No dirt or oxidation on the terminal or copper strip.
   c. Wire must fit tightly in the terminal or copper strip.
3. Apply heat and solder to the terminal.
   a. Hold the iron so the puddle of solder on the iron touches the connection.
      This allows a fast transfer of heat.
   b. Allow solder to flow around the wire and terminal.

   Do not remove the heat until the solder looks smooth and shiny.

Self Quiz

1. Solder melts at approximately ____° F.
2. _____ is added with the solder to keep the connection clean while soldering.
3. _____ must be worn to avoid solder in the eyes.
4. Cleaning the tip of the iron with a damp sponge and adding a drop of solder is called _____ the iron.
5. When not in the hand the iron must be in the _____.

INST. CHECK ( ) Points: ( )

EXPLORATION SHEET #____ SOLDERING PRACTICE NAME_____

Learning Activities

You will make acceptable solder connections on tie strips and circuit boards.

The parts kit should include:

1. soldering iron
2. solder
3. wire
4. various components (resistors, capacitors, etc.)
5. circuit board
6. tie strip board

Proceedure

1. The instructor will pass around a mounted model circuit board and tie strip board.
   Study the model.
   Copy the number of connections and quality of soldering. (Or do better if possible.)

2. Be sure to follow the soldering proceedure on the Exploring Concepts sheet.

3. Follow the instructor's example if a soldering demonstration is given.

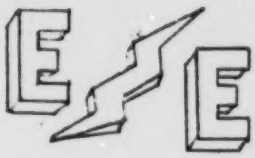
4. Work safely:
   don't touch hot irons
   don't touch hot connections
   support your work with clamps or other means. (A board that slips could cause you to burn yourself.)
   don't drip hot solder
   don't waste solder-- only a small amount is needed for each connection.

5. Have the instructor grade your tie strip and circuit board. [ ] tie strip [ ] circuit board

6. After your work has been graded, take the wire off of the tie strip board.
   Return the materials to the parts kit.

INSTRUCTOR CHECK

Total points this section: ( )



PROJECT: POCKET SIREN

This is a really fun project. It's a small, electronic siren that makes the same sound as an ambulance, a police car, or a fire engine. The siren can be very loud when used in connection with a big amplifier system. However, you have to be careful that it doesn't get too loud, or your neighbors or the police may not like it.

The assembly is straight forward and simple, but it is necessary to carefully watch the connection of the transistor leads and the polarity of the electrolytic capacitor.

STAGE I: CHECKING AND IDENTIFYING COMPONENTS

RESISTORS

	check off	Value	Fill in the correct color code for each resistor		
one		R_1 10 K Ω			
one		R_2 100 K Ω			
one		R_3 100 K Ω			
one		R_4 15 Ω			

CAPACITORS

	check off	Value	Draw Pictorial	Draw Schematic	Identify the Type
one		C_1 50 μfd 25 volts			
two		C_2, C_4 .1 μfd			
one		C_3 .05 μfd			

TRANSISTORS

	check off	Type	Draw Pictorial Show EBC Leads	Draw Schematic	Type of Transistor Outline
one		Q_1 NPN			
one		Q_2 PNP			

SPEAKER

	check off	Size and Impedence	Draw Pictorial (Show Speaker Leads)	Draw Schematic	Type
one		2½" 8ΩZ			

9-17-1

POCKET SIREN PROJECT

SWITCH

	check off	Name	Draw Pictorial	Draw Schematic	Type
one		push button			

HARDWARE

	check off	
.		9 volt battery connector
one		silk screened, printed circuit board
one		plastic box
four		machine screws 4-40 x $\frac{5}{8}$ "

INSTRUCTOR CHECK

STAGE II: PRINTED CIRCUIT BOARD PREPERATION

____ 1. Etch P. C. board. Be sure no painted lines are touching and the paint is not scratched. (Several methods of etching can be used. Check first with your instructor.)

____ 2. Drill component holes in the circuit board. Use a $\frac{3}{64}$ " or #56 drill. Look at the shop model for the location of the holes.

____ 3. Use a chassis punch to make a $\frac{7}{8}$" hole for the speaker. Look at figure A for the location of the hole.

____ 4. Clean your circuit board with steel wool. Be sure the copper lines are bright and shiny.

STAGE III: MOUNTING AND SOLDERING THE COMPONENTS

Be sure all of your component leads are cleaned or scraped before soldering.

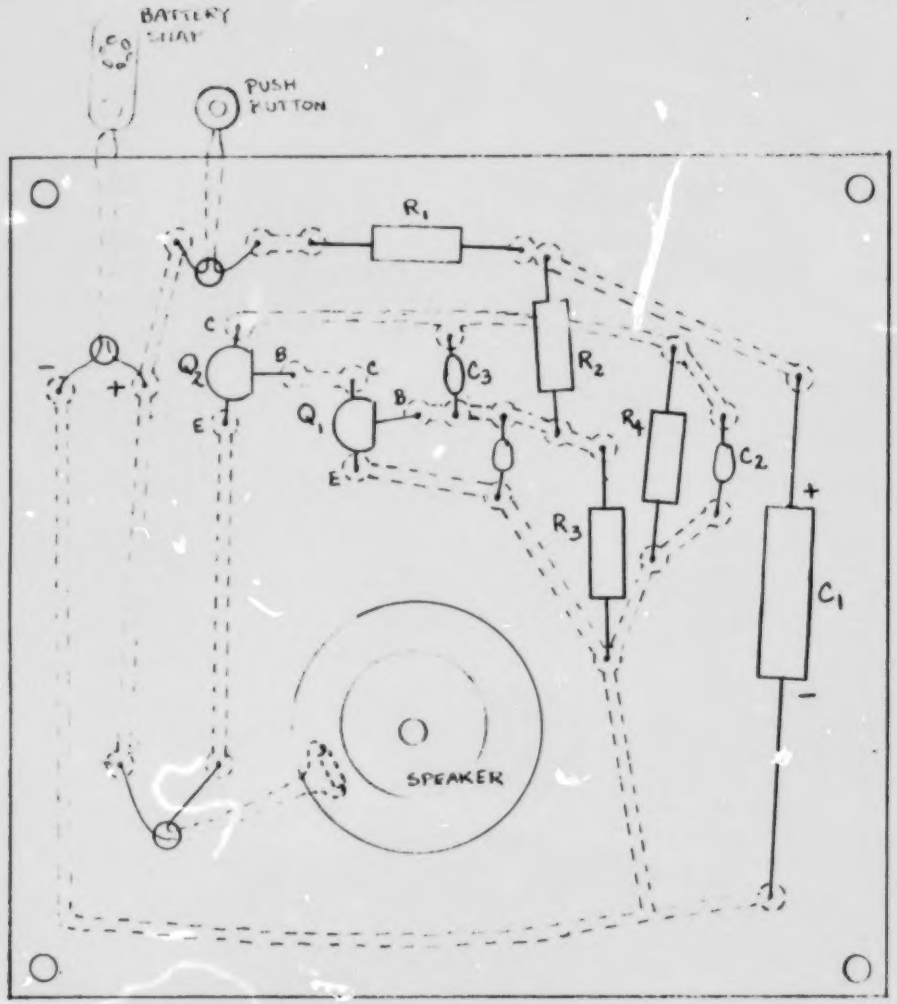
CAUTION: Make SURE all of the components on the P. C. board are mounted on the side OPPOSITE the copper lines. This is the component side.

____ 1. Bend the leads of R_1 (10 KΩ). Insert it in the holes. Look at the pictorial diagram for the location. Solder it in place.

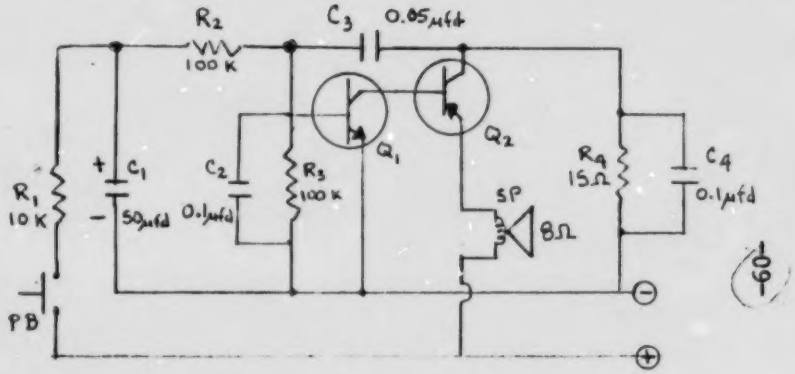
____ 2. Repeat the process described above for R_2 (100 KΩ), R_3 (100 KΩ), and R_4 (15Ω).

____ 3. Have your instructor check your soldering quality before you go on to the next step. INSTRUCTOR OK [ ] .

____ 4. Bend the leads on capacitor C_1 (50 μfd). Insert it in the holes. Observe the polarity (-) and (+). Solder it in place.



Component Side Pictorial



Schematic

FIGURE A

A-117-d

D-41-17

____ 5. Bend the leads on C_2 (.1 μfd), C_3 (.05 μfd). and C_4 (.1 μfd). Insert these capacitors in the holes. Solder them in place.

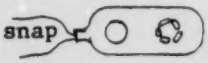
____ 6. Insert Q_1 NPN transistor in the holes. Keep the transistor about ¼" above the board. Make sure the E-B-C leads are in the correct holes. Solder it in place.

____ 7. Repeat step 6 for Q_2 PNP transistor.

____ 8. Cut 2 lengths of #22 stranded wire about 4" long each. Strip about 1/8" of insulation off of each end:

Solder these wires to the P B switch and then to the P. C. board. See pictorial in figure A.

____ 9. Cut 2 lengths of #22 stranded wire about 3½" long each. Strip 1/8" insulation from each end. Solder these wires to the 2¼" speaker and then to the P. C. board. See pictorial in figure A.

____10. Take the 9 volt battery snap  and solder it to the P. C. board.

Remember, the black wire goes to the - side and the red goes to the + side. Look at the pictorial in figure A. After you finish step 10, take your soldered circuit board and compare it with the shop model.

INSTRUCTOR CHECK

____12. Connect your siren to a 9 volt battery. Push the switch to see if it works. Good luck!

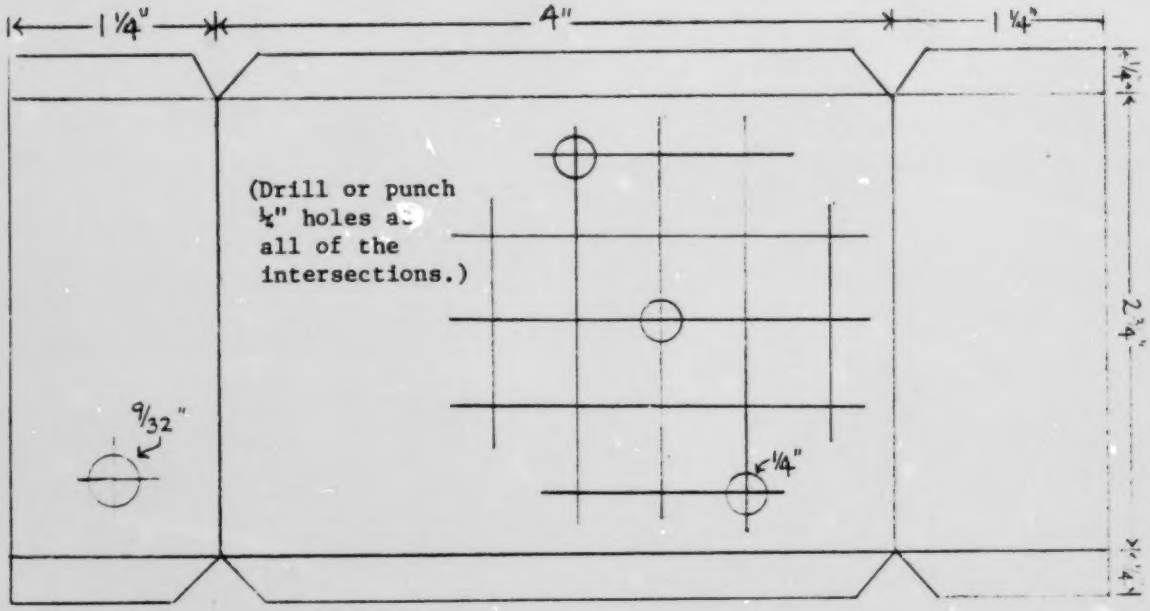
STAGE IV: CASE CONSTRUCTION

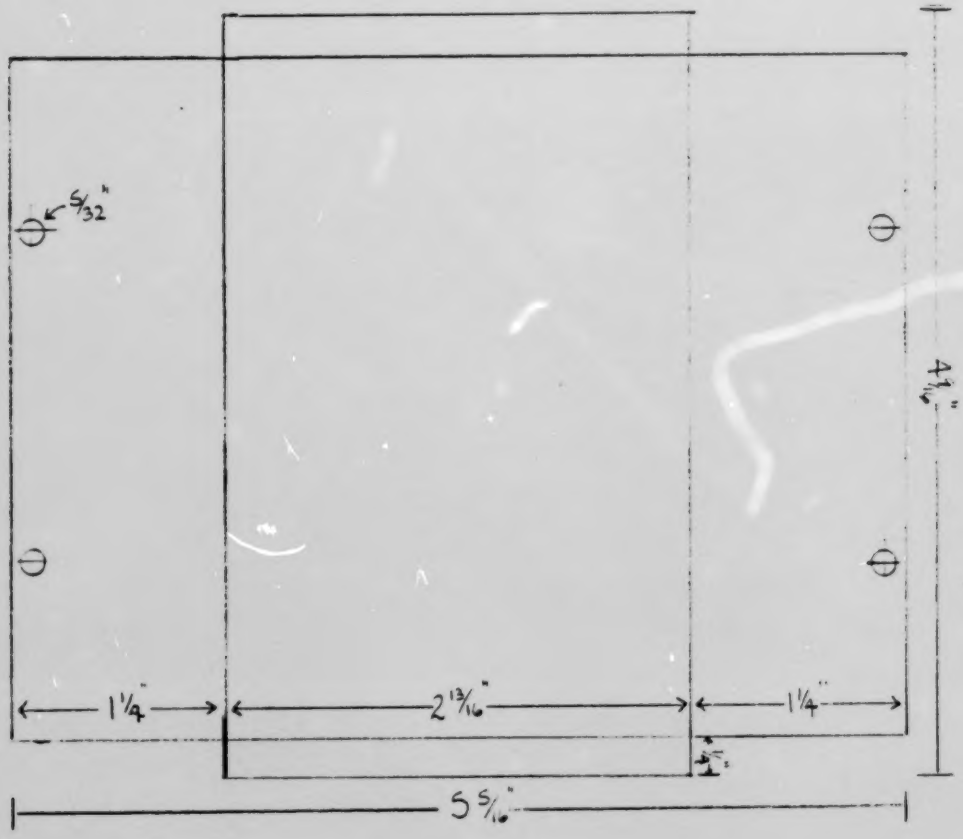
After you have your siren working, you can put it in many different cases-- for example metal, plastic, or wood can be used.

Your instructor will show you how to make a case for your siren.

POCKET SIREN PROJECT

Metal Box Pattern





LEVEL II

Exploration Sheet List

CONCEPT LIST:

1. Using the VTVM to Take Voltage Measurements
2. Ohm's Law and Power Relationships
3. Series Circuits
4. Parallel Circuits
5. Electrical Safety Information
6. A/C Voltages
7. Inductive Devices and Transformers
8. Testing Diodes
9. Power Supply Rectification
10. Set Up of the EICO 460 Oscilloscope
11. Testing Transistors
12. Logic Gates
13. The TV Jammer Project

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Using the VTVM to take Voltage Measurements

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will measure unknown voltages from a group of 5 batteries.

The Student Will:

1. Review the voltmeter set up procedure.
2. Identify the polarity of the meter leads.
3. Select proper meter ranges.
4. Test the voltages of 5 unmarked batteries.
5. Return the meter to high range after the meter has been read for each battery.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Ohm's Law and Power Relationships

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will use Ohm's Law and the Power Formulas.

The Student Will:

1. Work out circuit problems using Ohm's Law and Power Formulas.
2. Connect a simple circuit and measure the voltage across it using a VTVM.
3. Use Ohm's Law to calculate the current in the same simple circuit.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Series Circuits

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will connect and work with a series circuit.

The Student Will;

1. Connect 3 resistors in series and measure the resistance of the combined resistors.
2. Add 3v (2 batteries) to the circuit and measure the voltage across each individual resistor in the series circuit.
3. Observe the relationship between individual voltage drops and total voltage drop to the voltage source.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Parallel Circuits

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will work with resistances and voltages in parallel circuits.

The Student Will:

1. Connect 3 resistors in parallel and use a VTVM to measure the voltage across each branch of the circuit.
2. Observe the relationship between the branches.
3. Connect 2 resistors in parallel.
4. Measure and calculate the total resistance of this parallel circuit.

CONCEPT

Electrical Safety Information

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will become aware of electrical safety.

The Student Will:

1. Participate in class discussion.
2. Read selected safety materials.
3. Watch safety film(s).
4. Demonstrate a minimum level of awareness and understanding of electrical safety.

CONCEPT

A/C Voltages

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will use an oscilloscope to see and a speaker to hear different A/C waveforms.

The Student Will:

1. Set up an audio generator to produce a 400 Hz sine wave and square wave.
2. Set up an oscilloscope to observe A/C waveforms.
3. Connect the oscilloscope to the audio generator and observe sine and square waveforms.
4. Connect a speaker to a sine wave output from the audio generator.
5. Vary the frequency upwards and downwards to test your hearing.

CONCEPT

Inductive Devices and Transformers

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will work with and observe the effect of a self inductance coil.

The Student Will:

1. Connect a neon lamp across an inductor.
2. Connect a battery and switch to the coil-lamp assembly.
3. Open and close the circuit and observe the self inductance effect.
4. Hold two fingers across the inductor and have someone else open and close the switch. Observe and feel the self inductance effect while the switch is open and closed.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Using Diodes

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will use and test a diode.

The Student Will:

1. Connect a series curcuit using 2 batteries, a diode and a lamp.
2. Try the diode in the circuit in both the reverse bias and forward bias directions.
3. Observe the results.
4. Using the ohmeter and diode only, test the diode's resistance in both the forward bias and reverse bias directions.
5. Observe how a good diode tests.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Power Supply Rectification

DEPTH OF INSTRUCTION

3

LEARNING ACTIVITIES

You will use an oscilloscope to observe rectification and filtering.

The Student Will:

1. Construct a basic ½ wave rectifier circuit using a 12 volt transformer, a diode, and a load resistor.
2. Use an oscilloscope to observe the waveform before and after rectification.
3. Add a filter capacitor to the circuit.
4. Observe the output of the filtered power supply with the oscilloscope.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Set Up of the EICO 460 Oscilloscope

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will set up a 460 EICO oscilloscope to show a sine wave.

The Student Will:

1. Complete a self quiz on the basic sections of an oscilloscope.
2. Follow a step by step procedure for operating a 460 EICO oscilloscope.

CONCEPT

Testing Transistors

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will test NPN and PNP transistors.

The Student Will:

1. Measure the forward and reverse resistance of the BE and BC junctions of NPN and PNP transistors.

2. Evaluate these measurements to determine the condition of the transistors.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

Basic Logic Gates

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will build and work with AND and OR circuits.

The Student Will:

1. Construct an AND gate circuit using two switches.
2. Complete a truth table for an AND gate.
3. Construct an OR gate circuit using two switches.
4. Complete a truth table for an OR gate.

INSTRUCTIONAL PLANNING SHEET

LEVEL II

CONCEPT

TV Jammer Project

DEPTH OF INSTRUCTION

2

LEARNING ACTIVITIES

You will build a device that will knock out TV and FM radio reception from up to 30 feet away.

The Student Will:

1. Check off and identify each component.
2. Prepare the printed circuit board.
3. Mount and solder the components.
4. Test the TV jammer for proper operation.
5. Experiment with the TV jammer on FM radio.
6. Convert the TV jammer to an FM transmitter.

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

USING THE VTVM TO TAKE VOLTAGE MEASUREMENTS

NAME_____

PERIOD_____

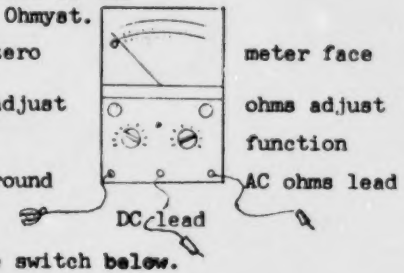
Exploring Concepts

Voltage measurements (electrical pressure) must be made on a live circuit, so you must be careful to protect yourself and the meter. These directions/explanations will help you develop safe working habits with the volt meter.

Check out a VTVM and a D cell battery.

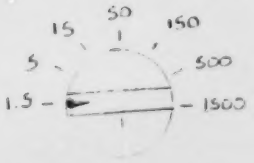
Setting up the VTVM for voltage measurements:

Review the parts of the WV-77 E volt Ohmyst.



Proceedure

1. Plug the meter into the 120 AC main.
2. Turn the function switch to DC+ and the range switch to 1.5 volts.
3. After the needle stabilizes, turn zero adjust so the needle rests on the left zero. We are using the second scale from the top called D.C or R.M.S. (See the drawing at the bottom of the page.)
4. Study the range switch positions. Only voltage ranges are shown in the drawing of the range switch below.
5. Turn the range to the 1.5 scale. Connect the battery to the VTVM with DC lead touching the + end of the battery and ground lead touching the - end of the battery. The needle will move up scale.
6. The voltage scales (DC or RMS) end in 5.0 and 1.5. When range is set on 5, 50, or 500 read the top part of the scale that ends with 5.0. When range is on 1.5, 15, 150, or 1500 read the lower part that ends with 15.
7. Range is on 1.5v, so we use the scale ending in 15. 15 is really 1.5 and, going down scale, 14 is 1.4v, 10 is 1.0v (or 1v).
8. The D cell pushed the needle just off the end of the scale so we know the voltage from the battery is over 1.5 volts.
9. Turn the range switch to the 5 volt scale. With nothing connected check the zero setting.
10. Connect the battery to the meter. Remember we are on the 5 volt scale. Now the needle does not go to the top of the scale.
11. The full scale reading is 5v. If you go down scale you can count 5v→4.5v→4v→3.5v→3v→2.5v→2v→1.5v. The needle should be here. A good D cell battery should read about 1.6 volts.
12. If you connect the battery with wrong polarity, the needle will try to go down instead of up.
13. Try to test the battery on the 15 volt range. Does the meter read the same? _____(yes or no)



Range Switch

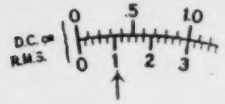
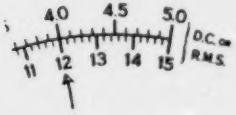
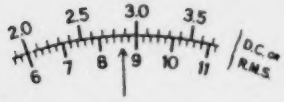
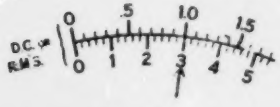
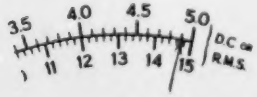
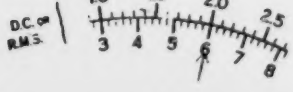
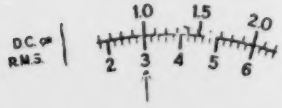
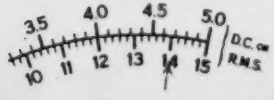
Voltage Scales

13. yes. The meter should read the same.

EXPLORATION SHEET #____ USING THE VTVM TO TAKE VOLTAGE MEASUREMENTS NAME_____

Self Quiz

Practice reading these voltages:

	Range	Volts
	15 v	_____
	15 v	_____
	50 v	_____
	1500 v	_____
	50 v	_____
	50 v	_____
	150 v	_____
	5 v	_____
	15 v	_____

INST. Points:

Learning Activities

You will measure unknown voltages from a group of 5 batteries.

You will need: VTVM
Set of 5 batteries (A,B,C,D) with no voltage markings

IMPORTANT: ALWAYS FOLLOW THIS PROCEEDURE

1. Set function on DC+ volts.
   Set range on 1500 volt scale. Always start with 1500v scale!
2. Connect battery A into the circuit using the DC and common ground leads. (Remember the + and - polarity.)
3. With the battery connected, turn the range switch down one step at a time until the needle is near the middle area of the scale. DON'T take a reading yet.
4. Disconnect the battery and check the zero. Adjust it if it is not exact.
5. Reconnect the battery and take the reading.
6. Write the reading in the answer space below.
7. Turn the range switch back to 1500v to be ready for the next battery meausrement.
8. Measure the voltage of the next battery carefully going through each of the 7 steps.

A [ ] B [ ] C [ ]

D [ ] E [ ]

Check in all materials.

INSTRUCTOR CHECK

Total points this section: [ ]

Self Quiz-
Learning Activity-
TOTAL POINTS

EXPLORATION SHEET #____

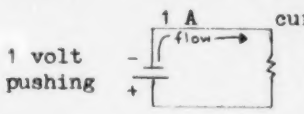
OHM'S LAW AND POWER RELATIONSHIPS

NAME_____

PERIOD_____

Exploring Concepts

In exploring sheets 2 and 3 you worked with current, voltage, resistance, and power relationships. Many years ago a scientist, George Ohm, put these relationships into mathematical expressions. He found out 1 volt would cause 1 ampere ( ) of current to flow through 1 ohm of resistance.



current flows

E = voltage
R = resistance
I = current

Formulas for Ohm's Law are: $E = IR$ $I = \frac{E}{R}$ $R = \frac{E}{I}$

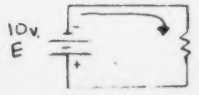
Use this memory circle:

for finding voltage, put a finger over the E and you get I x R.
for finding current, put a finger over the I and you get $\frac{E}{R}$.
for finding resistance, put a finger over the R and you get $\frac{E}{I}$.

-79-

Study each circuit below to see how each answer is calculated.

finding current

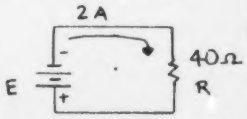


$I = \frac{E}{R}$

$I = \frac{10v}{10\Omega}$

$I = 1\ A$

finding voltage

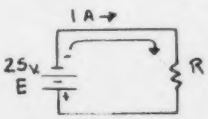


$E = I \times R$

$E = 2 \times 40$

$E = 80v$

finding resistance



$R = \frac{E}{I}$

$R = \frac{25v}{1A}$

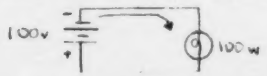
$R = 25\Omega$

Learning how to find power is another important factor in electrical circuits. Power is measured in watts. To find power (P), multiply current (I) x voltage (E). P = I x E.

Use this memory circle for finding power:

P = I x E
P = 2A x 100v
P = 200w This lamp uses 200 watts of power.

Find the current through this bulb:

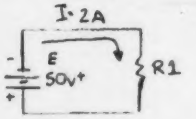


$I = \frac{P}{E}$ $\frac{100w}{100v} = 1$ Amp

Study each circuit and work out each problem before you take the self-test.

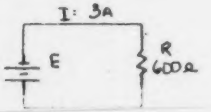
Self Quiz

Solve these problems:

1. 

Find R

R=_____

2. 

Find E

E=_____

3. An electric toaster rated at 1200 watts is connected to a 120 volt source.
How much current is it using?
I = _____

4. Complete the following formulas:

E = R =

I = P =

INSTRUCTOR CHECK

Total points this section:

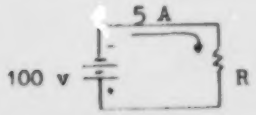
EXPLORATION SHEET #____ OHM'S LAW AND POWER RELATIONSHIPS NAME_____

Learning Activities

You will use Ohm's Law and the Power Formulas.

I.

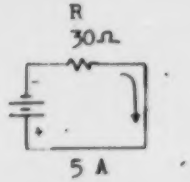
Using Ohm's Law and Power Formulas, see if you can work out these circuit problems:



R = _____

I = _____

P = _____



E = _____

II.

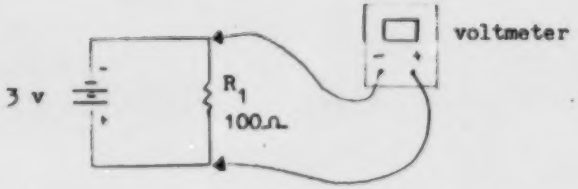
Applying Ohm's Law

Check out a VTVM

108

The parts kit should include:

1. 2 D cell batteries with holders
2. 100Ω resistor
3. hook-up wire



1. Connect the circuit as shown.

2. Measure the voltage across R_1.

   Record the voltage: _____v

3. Use Ohm's Law to calculate the current through R_1.

   $I = \frac{E}{R}$ Current (I) = _____A

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

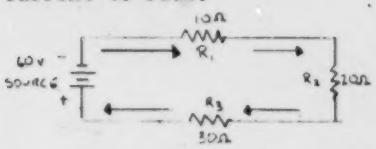
SERIES CIRCUITS

NAME_____

PERIOD_____

Exploring Concepts

Series circuits have ONLY ONE PATH for current to flow.



In this circuit the current leaves the battery and flows through each resistor. If any part of the circuit is broken the total current will be stopped.

Notice each resistor must be numbered (R_1, R_2, R_3, etc.)

You can find the total resistance (R_T) in series circuits by adding all the resistor values.

$$R_T = R_1 + R_2 + R_3$$

$$= 10\Omega + 20\Omega + 30\Omega$$

$$R_T = 60\Omega \text{ circuit resistance}$$

You can find the total current (I_T) in the series circuit by dividing the source voltage (E_S) by the total resistance (R_T).

$$\text{Ohm's Law: } I_T = \frac{E}{R} = \frac{60v}{60\Omega} = 1 \text{ Amp}$$

As current passes through a resistor, a certain amount of energy is used and a certain amount of pressure (or voltage) is lost. This voltage drop (or loss) is calculated by Ohm's Law:

$$E = I \times R$$

The total voltage drop in any series circuit EQUALS the voltage source.

We can prove this statement with these steps:

1. Find the total current (I_T).

$$I_T = \frac{E_{source}}{R_{TOTAL}} = \frac{60v}{60\Omega} = 1 \text{ A current}$$

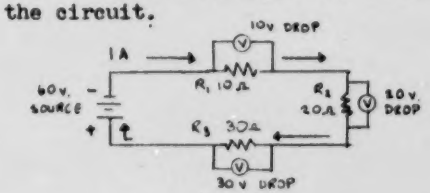
2. Find the voltage drop across each resistor. (E_{R_1} means voltage across resistor R_1).

$$E_R = I\,R_1 = 1A \times 10\Omega = 10v$$

$$E_R = I\,R_2 = 1A \times 20\Omega = 20v$$

$$E_R = I\,R_3 = 1A \times 30\Omega = 30v$$

3. Now add up the voltage drops around the circuit.



$$E_{source} = E_{R_1} + E_{R_2} + E_{R_3}$$

$$= 10v + 20v + 30v$$

$$E_S = 60v$$

Voltage drops will always equal the voltage source.

REMEMBER In series:

- **Resistance adds $R_T = R_1 + R_2 + R_3$
- **Current stays the same $I_T = I_1 = I_2 = I_3$
- **Total voltage drop equals the voltage source $E_T = E_{R_1} + E_{R_2} + E_{R_3}$

Self Quiz

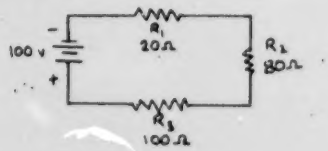
1. In a series circuit,

   R_T= _____.

2. The _____ is the same when measured at any point in the series circuit.

3. The _____ always equals the source voltage in a series circuit.

4. Find the total current and resistance of this circuit.



   I_T_____ R_T_____

5. Draw a series circuit schematic with a switch, 2 lamps, and one battery.

INST. CHECK Points:

EXPLORATION SHEET #____ SERIES CIRCUITS NAME_____

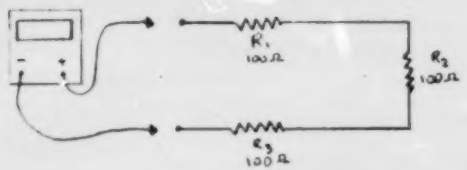
Learning Activities

You will connect and work with a series circuit.

The parts kit should include:

1. VTVM
2. 3 100Ω resistors
3. 2 D cells
4. connection wire

1. Connect three 100Ω resistors in series as shown.

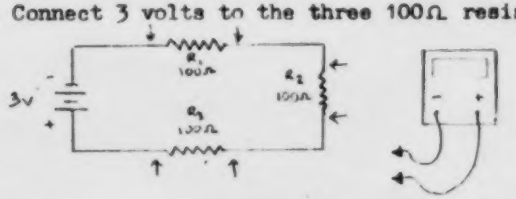


2. Measure the three resistors in series using your ohmmeter.

   Does the measured value come close to 300Ω ?

   _____

3. Connect 3 volts to the three 100Ω resistors.



4. Measure and record the voltage drop across each resistor.

   E_{R_1} _____ E_{R_2} _____ E_{R_3} _____

5. Add all the voltage drops to find the total voltage drop in the circuit.

   E_T _____

6. Do these voltage drops equal the source voltage?

   _____

7. Return all the materials to the parts kit.

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

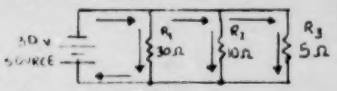
EXPLORATION SHEET #____
PARALLEL CIRCUITS

NAME_____
PERIOD_____

Exploring Concepts

When several components are connected to the same voltage source, they are connected in parallel, or 'side by side'.

In this circuit you have 3 resistors connected in parallel. Each resistor creates a path for current to flow.



Each resistor has the same voltage across it (30v).

In all parallel circuits the voltage stays the same across each branch. The formula for voltage in parallel circuits is:
$E_T = E_{R1} = E_{R2} = E_{R3}$ or VOLTAGE STAYS THE SAME.

Total current in parallel circuits can be found by adding the individual branch currents: $I_T = I_1 + I_2 + I_3$ or CURRENT ADDS.

Calculating current in parallel (Fig. A):

1. Use Ohm's Law to find the current through each individual branch.

$I_1 = \frac{E_s}{R_1} = \frac{30v}{30\Omega} = 1\ A$

$I_2 = \frac{E_s}{R_2} = \frac{30v}{10\Omega} = 3\ A$

$I_3 = \frac{E_s}{R_3} = \frac{30v}{5\Omega} = 6\ A$

2. Find the total current of the circuit by adding the individual currents.

$I_T = I_1 + I_2 + I_3$ or

$I_T = 1A + 3A + 6A = 10\ A$

$I_{Total} = 10$ Amps

Remember: Current adds in parallel.

Notice: The branch with the least resistance has the most current flow.

Total resistance in parallel circuits can be found by using Ohm's Law (Total Current Method).

Calculating total resistance (Fig. A):
Using Ohm's Law

$R_T = \frac{E_s}{I_T} = \frac{30v}{10A} = 3\Omega$

When current goes up↑, resistance goes down↓ so

The total resistance in any parallel circuit is always LESS than the smallest resistance.

- - - - - - - - - - - - - - - - - -

Here is another way to find total resistance when you have two resistors in parallel.

$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$

$R_T = \frac{10 \times 40}{10+40} = 8\Omega$

The conductance method of finding resistance will be presented later.

Self Quiz

1. The total resistance of any parallel circuit must be _____ than the value of any resistor.

2. The voltage will always be _____ across any resistance load in a parallel circuit.

3. To find the total current in a parallel circuit you _____ the branch currents.

4. Find the total current and total resistance in this circuit.

I_T_____

R_T_____

INSTRUCTOR CHECK

Total points this section: ( )

EXPLORATION SHEET #____ PARALLEL CIRCUITS NAME_____

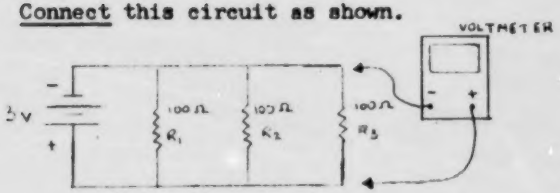
Learning Activities

You will work with resistances and voltages in parallel circuits.

The parts kit should include:

1. VTVM
2. 3 100Ω resistors
3. 1 1000Ω resistor
4. 2 D cells
5. connection wire

Connect this circuit as shown.



1. Use the VTVM to measure the voltages across the resistance loads in the circuit.

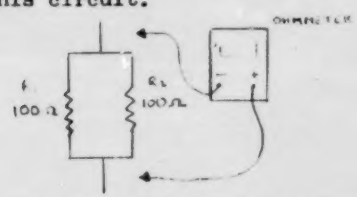
E_{R_1}_____

E_{R_2}_____

E_{R_3}_____

Are all of the voltages equal? _____

Disassemble the previous circuit and connect this circuit.



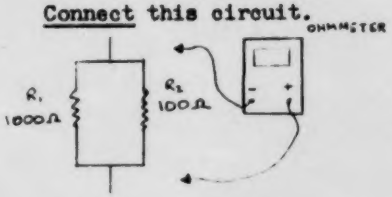
2. Use the ohmmeter to measure the resistance

R_T _____ measured

3. Calculate the resistance for the same circuit. Use the formula at the bottom of the page.

R_T _____ calculated

Connect this circuit.



4. Measure the resistance across the circuit.

R_T _____ measured

5. Calculate the resistance for the circuit.

R_T _____ calculated

The measured values should be within 10% of the calculated values.

Formula for calculating resistance: $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$

6. Return the parts to the parts kit.

INSTRUCTOR CHECK_____ Total points this section: ( )

-84-

130

131

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

ELECTRICAL SAFETY INFORMATION

NAME_____

PERIOD_____

Exploring Concepts

Most fatal electric shocks happen to people who should know better. Here are some facts about electricity and the body that should make you think twice before taking that last chance.

Even though you have not yet studied a lot about electricity, you have already heard the words voltage and current many times.

THE FATAL CURRENT

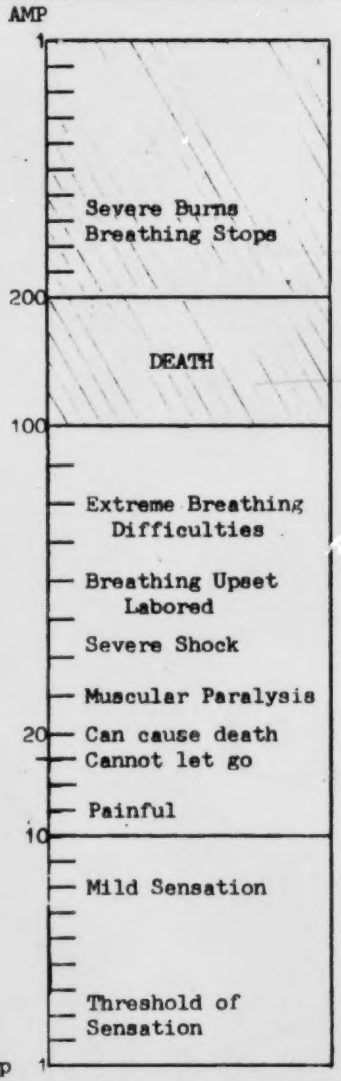
It seem like a shock of 10,000 volts would be more deadly than 100 volts. This is not true. People have been electrocuted by appliances using ordinary AC house currents of 120 volts and by electric industrial apparatus using as little as 42 volts direct current (DC). A shock's intensity depends on the amount of current forced through the body, not the voltage. Any electrical device used on a house wiring circuit can transmit a fatal current—a current that kills. People often become less careful when working on circuits with low voltage because they think there is not enough current to be dangerous. This is not true: low voltage can produce high current and <u>can</u> KILL just as high voltage can KILL.

The chart shows the effect of different amounts of current on the body.

Shock is more severe as the current rises. At values as low as 20 milliamps (mA) breathing becomes labored (difficult) and finally stops completely, even at values below 75 mA.

As the current nears 100 mA, ventricular fibrillation of the heart occurs—an uncoordinated twitching of the heart's chamber walls.

Most of the time NOTHING can be done to save the victim.



At about 200 mA, muscular contractions are so severe that the heart is forcibly clamped (stopped) during the shock. This clamping protects the heart from going into ventricular fibrillation, and the victim's chances for survival are better. Artificial respiration will usually revive the victim.

DANGER—LOW VOLTAGE

It is common knowledge that the surviving victims of high voltage shock respond to artificial respiration more readily than the victims of low voltage shock. The reason may be the heart clamping from the high current densities in high voltages.

It is important to remember that <u>every electrical circuit has the ability to kill</u>, whether the voltage is high or low. But if we are careful it will work for us and not against us.

After a person is knocked out by an electric shock it is impossible to tell how much current passed through the vital organs of the body. In all cases, ARTIFICIAL RESPIRATION MUST BE GIVEN IMMEDIATELY IF BREATHING HAS STOPPED.

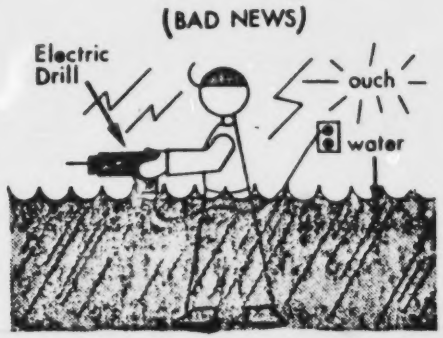
Most circuits using transistors and 'ICs' (integ ated circuits) use voltages below 30v. In most cases it is very hard to even feel a shock at this level. So most circuits are safe to touch. But WATCH OUT for the power supply. The input on power supplies is the 120v AC from the power mains.

Know the parts of a circuit that can shock you. It is funny to see a person jump, but it may also be deadly.

EXPLORATION SHEET #____ ELECTRICAL SAFETY INFORMATION NAME_____

Exploring Concepts

When working with portable power tools, make sure they are grounded. Also be sure you have complete control at all times. NEVER use portable power tools while standing in water!



Never allow any part of your body to become part of a hot or live circuit (circuit with electricity flowing through it).

When it is necessary to work on hot wires, be sure you:
touch only one wire at a time
stand on a dry surface, rubber if possible
NEVER allow your body to become part of the circuit.

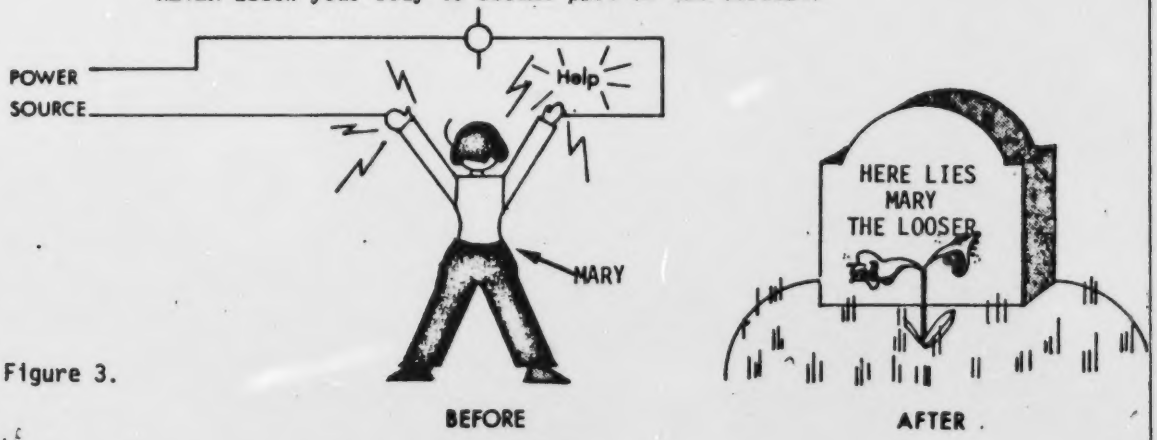


Figure 3.

REMEMBER: Know the circuit you are working with so you don't become a part of it!

Self Quiz

1. It is the _____ that kills.
2. People have been killed by voltages as low as _____v.
3. When using power tools (drills, sanders, etc.), be sure the case is _____.
4. If it is necessary to work on live circuits, be sure your body doesn't _____ _____ of the circuit.
5. Shock victims should receive _____ to revive them.
6. Working with power tools on a wet floor is _____.
7. Voltages below _____v are not shock hazards.
8. Even in low voltage circuits, 11 120v can be found in the _____ _____.

INSTRUCTOR CHECK

Total points this section: ____

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

AC VOLTAGES

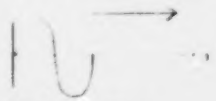
NAME_____

PERIOD_____

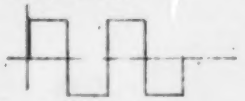
Exploring Concepts

AC voltage is voltage that is always changing in magnitude and direction.

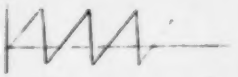
There are several types of AC voltages used in electronics. We can look at these voltage waveforms on an oscilloscope. Here are some of these waveforms:



AC Sine Wave
Most common voltage in homes and factories.



Square Wave
Used extensively in audio testing and computers.



Sawtooth Wave
Used in TVs, radar receivers, and other electronic devices.

Here are some important terms used to describe AC:

A cycle contains one positive alternation and one negative alternation of the voltage.

The time (t) needed to complete one cycle is the period (T in seconds).

The rate at which the cycles are produced is called frequency (F).

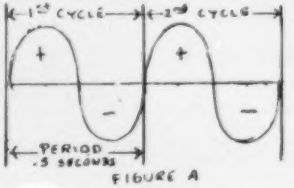


FIGURE A

The base unit for frequency is the Hertz (Hz). One Hertz equals one cycle per second.

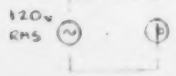
The wave form in fig. A has a time period of .5 seconds which equals 2 cycles per second or 2 Hz. An average person can hear sound frequencies from 20 Hz to 20 KHz.

We can discuss the amplitude (height) or voltage of an AC wave in several ways:

Effective or RMS = .707 x Peak Voltage
Peak Voltage = 1.41 x RMS
Peak to Peak Voltage = 2 x Peak Voltage

When you turn on a lamp in your home, the lamp has 120v RMS across it and peak values also.

example circuit



The light has 120v RMS across it.
Peak Voltage = 1.41 x RMS
= 1.41 x 120v = $169.2v_p$
Peak to Peak Voltage = 2 x Peak Voltage
= 2 x 169.2
= $338.4v_{p-p}$

We always assume that AC is in RMS units unless the subscript P-P or P is included

This is the symbol used to represent AC voltages.

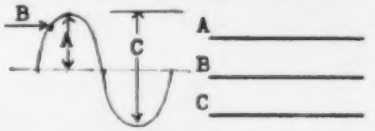
Self Quiz

1. A complete AC cycle contains one _____ alternation and one _____ alternation.

2. The time required to complete one cycle is called a _____.

3. The rate at which cycles are produced is called _____.

4. Name these voltage points:



5. The average person can hear frequencies from 20 Hz to _____Hz.

INSTRUCTOR CHECK

Total points this section:

EXPLORATION SHEET #____ AC VOLTAGES NAME_____

Learning Activities

You will use an oscilloscope to see and a speaker to hear different A/C frequencies.

The parts kit should include:

1. audio generator
2. 4" speaker
3. oscilloscope and test leads

Connect the following:

audio gen. scope

A. Set the audio generator for 400 Hz sine wave.

B. Connect the audio generator output to the vertical input of the scope. Observe the waveform and draw a picture of it in the box below.

Name the waveform _____

C. Switch the audio generator to square wave output. Observe the waveform and draw a picture of it in the box below.

Name the waveform _____

D. Disconnect the scope from the audio generator

E. Connect the speaker to the audio generator output.

a.f. gen. speaker

F. Set the audio frequency generator to sine wave 100 Hz.

G. Adjust the generator output to highest voltage.

H. Vary the frequency from 100 Hz to 20 KHz.

Record the highest frequency that you can hear.

I. Disconnect the speaker from the audio generator. Put away all of the materials.

INSTRUCTOR CHECK

Total points this section:

Self Quiz- - - - - -( )
Learning Activity- -( )
TOTAL POINTS - - - -( )

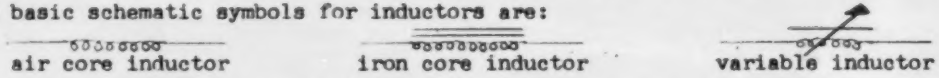
EXPLORATION SHEET #____
INDUCTIVE DEVICES AND TRANSFORMERS

NAME_____
PERIOD_____

Exploring Concepts

Inductance is the ability of a conductor to produce an induced voltage when the current varies. This ability of a conductor to induce a voltage in itself is called 'self inductance'. The letter symbol for inductance is "L" and its unit is called a Henry (H).

The basic schematic symbols for inductors are:



air core inductor iron core inductor variable inductor

Self inductance: Here are 3 drawings of the same circuit under different conditions.

1. In Fig. A, the switch closes. The magnetic field grows and expands outward. A slight counter voltage is induced.
2. A few seconds later, (Fig. B), the magnetic field becomes steady. The coil remains charged, ready to be released.

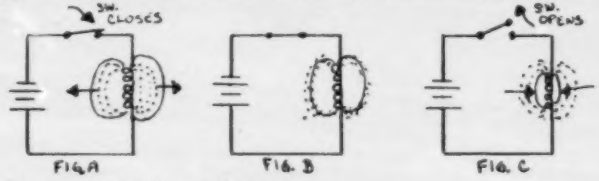


Fig. A Fig. B Fig. C

3. As the switch is opened, (Fig. C), the magnetic field collapses producing a high inductive kick. This induced voltage is called self inductance.

Mutual inductance: One coil can induce a magnetic field in another coil. This is called mutual inductance. Mutual inductance occurs when a changing magnetic field of one coil is coupled to another coil. (Fig. D).

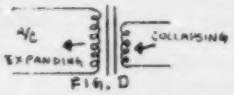


Fig. D

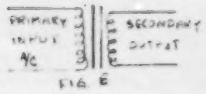


Fig. E

Fig. E shows the schematic symbol for a transformer. There are two windings. The primary winding goes to the input A/C voltage. The secondary winding goes to the output load circuit.

One of the major uses of a transformer is its ability to step up or step down a voltage.

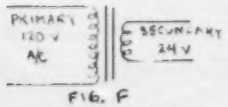


Fig. F

A step down transformer has fewer turns of wire on the secondary than on the primary.
The voltage is stepped down. (Figure F).

Fig. G

A step up transformer has more turns of wire on the secondary than on the primary.
The voltage is stepped up. (Figure G).

Self Quiz

1. The unit of inductance is called a _____.
2. The letter symbol for inductance is _____.
3. The ability of a coil to induce a voltage within itself is called _____ _____.
4. Name these transformers:

A _____

B _____

5. Draw a schematic symbol for the following:
   A. Air core inductor_____
   B. Iron core inductor_____
   C. Variable inductor_____

INSTRUCTOR CHECK

Total points this section:( )

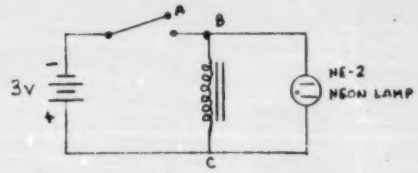
EXPLORATION SHEET #____ INDUCTIVE DEVICES AND TRANSFORMERS NAME_____

Learning Activities

You will work with and observe the effect of a self inductance coil.

The parts kit should include:

1. 2 D cells
2. 1.2 Henry inductor
3. neon lamp
4. switch
5. Connection wire



A. Connect a neon lamp across the 1.2 Henry inductor coil.

B. Connect the positive side of the battery to point C. Connect the negative side of the battery to the switch.

C. Open and close the switch alternately for a few seconds.

D. What does the neon lamp do?

_____

_____

E. Hold your fingers across the inductor at points B and C.

F. Have another person alternately open and close the switch.

G. Explain what happened.

_____

_____

_____

H. Disassemble and return all of the materials.

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

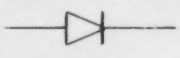
TESTING DIODES

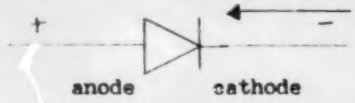
NAME_____

PERIOD_____

Exploring Concepts

Diodes are solid state devices which allow current to flow ONLY in one direction.

The symbol used for diodes is:  or



The arrow shows the direction of current flow through a diode.

Fig. A

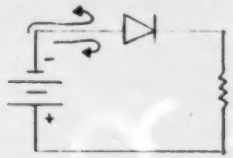


Fig. B

In Fig. A the current flows from cathode to anode. This is called forward bias. The diode has low resistance. It allows current to flow through the circuit.

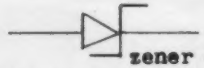
In Fig. B the diode does not allow the current to flow. The current is blocked. This is called reverse bias. The diode has high resistance.

-91-

Diodes can be used for many other functions such as rectification, switching, voltage regulation, etc.

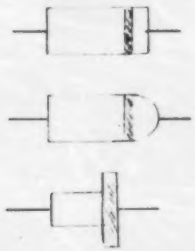
Here are some commonly used diode symbols:

Light Emitting Diode



Voltage Regulator

Diodes have many possible package shapes. Here are a few that you may see. The first type is the most common. The line on the case indicates the cathode end of the diode.



Self Quiz

1. Diodes allow current to flow in _____ direction.

2. When a diode conducts, the current flows from _____ to _____.

3. Name three functions of a diode: A_____

   B_____

   C_____

4. Draw a schematic symbol for a diode.

INSTRUCTOR CHECK

Total points this section:

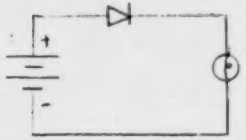
EXPLORATION SHEET #____ TESTING DIODES NAME_____

Learning Activities

You will use and test a diode.

The parts kit should include:
1. diode
2. 2 D cells
3. 1 lamp
4. VTVM or VOM

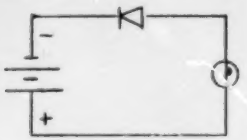
1. Connect the following circuit.



forward bias

Does the lamp light?_____

2. Connect the following circuit.



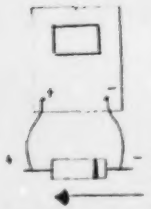
reverse bias

Does the lamp light?_____

Conclusion: A diode conducts when forward biased.
A diode does not conduct when reverse biased.

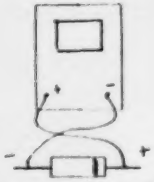
3. Check the diode with an ohmmeter.

Set the ohmmeter on Rx1000 Ω range.
Check the diode both ways.
Record the resistances.



_____ Ω
resistance

Fig. A



_____ Ω
resistance

Fig. B

In Fig. A the diode should measure low resistance, about 2 - 6 KΩ.
In Fig. B the diode should measure very high resistance or infinite ohms.

a good diode has low resistance one way and high resistance in the other direction.

INSTRUCTOR CHECK ( )
Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

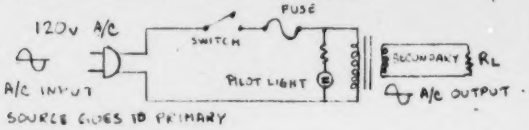
EXPLORATION SHEET #____
POWER SUPPLY RECTIFICATION

NAME_____
PERIOD_____

Exploring Concepts

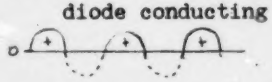
The purpose of a power supply is to produce continuous DC voltage from an AC source. Power supplies are sometimes called 'battery eliminators'.

The first component in the power supply is the transformer. Its purpose is to step up or step down A/C line voltages.



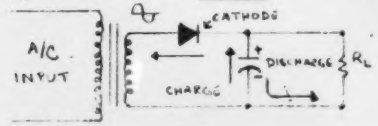
(R_L represents a load connected to the secondary. It could be a radio, lamp, etc.)

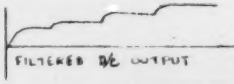
Another component in power supplies is the diode. The function of a diode in power supplies is to convert Alternating Current to Direct Current. Remember, a diode only lets current flow one way. A/C goes in 2 directions and D/C only 1 direction. This process of converting A/C (2 ways) to D/C (1 way) is called rectification.



1. When point A is positive during the first half cycle, the diode conducts.
2. This causes a voltage drop across R_L.
3. When point A is negative, the diode will not conduct.
4. The negative half of the AC has been removed or rectified.

A third component is the electrolytic capacitor. One of the functions of an electrolytic capacitor is to filter or smooth out the pulsating DC.





output voltage will look like this

1. When the diode conducts (+ +) the capacitor is being charged to the input AC peak value.
2. When the diode stops conducting on the negative half (- -), the capacitor discharges.
3. The capacitor is constantly charging and discharging to maintain filtered DC output.
4. This type of power supply uses half wave rectification. Only the positive half of the AC sine wave input is used.
5. Full wave rectification will be presented later.

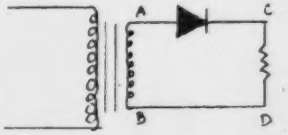
Self Quiz

1. Changing AC voltage to DC voltage is called _____.

2. Match the component with the correct function:

___switch	A. protects
___diode	B. indicator
___fuse	C. turns on/off
___pilot light	D. rectifies

3. Draw the correct waveforms for this circuit:



Across points A and B

Across points C and D

INSTRUCTOR CHECK

Total points this section:

EXPLORATION SHEET #____ POWER SUPPLY RECTIFICATION NAME_____

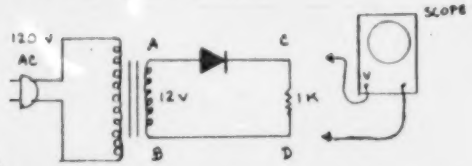
Learning Activities

You will use an oscilloscope to observe rectification and filtering.

The parts kit should include:

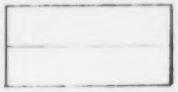
1. diode
2. 12v transformer
3. 1000 μfd capacitor
4. line cord
5. 1 KΩ resistor
6. hook up wire

Build this circuit.



1. Use your oscilloscope to see what the voltage looks like at points A and B, C and D.

Draw the waveform across A and B.

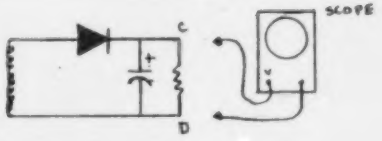


Name this voltage. _____

Draw the waveform across C and D.

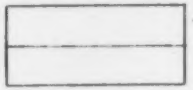
Name this voltage. _____

2. Add a capacitor to this circuit



Be sure to observe the polarity of the capacitor.

Draw the waveform across C and D.



Name this voltage. _____

INSTRUCTOR CHECK

Total points this section: ( )

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____
SET UP OF THE
EICO 460 OSCILLOSCOPE

NAME_____
PERIOD_____

Exploring Concepts

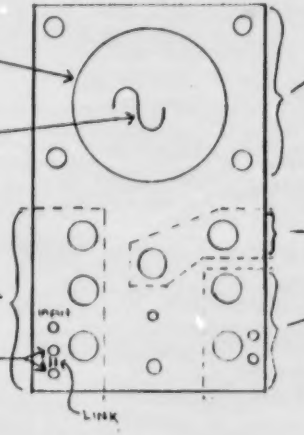
Now that you have used voltmeters and Ohmmeters we are ready to use the oscilloscope. The Oscilloscope can measure voltage, temperature, time, R.P.M., weight, light intensity, and other values. So, it can be used to test many things like computers, stereos, cars, radios, or any device that carries an electrical impulse.

To show measurements, the scope uses a line called a'trace' on a TV type screen instead of a needle on a scale. This is because the oscilloscope can show voltage changes over a period of time. Sometimes the time period is very short-- as short as a millionth of a second. This means the trace on the screen must go very fast. Some scopes are very fast and are used for computer repair, others are slower and can be used for stereo and radio repair.

We will start our oscilloscope experience with the EICO #460. It is a slower type of scope.

The oscilloscope has many controls. This makes it a little hard to learn to use. To be really good at using a scope, you should know what each control does. It is best to start with a simple set up and advance from there.

The 460 EICO is like most general purpose oscilloscopes because it has all of the sections common to every scope. Let's look at the sections of the 460 scope.



'CRT' cathode ray tube shows the information.

Trace. The moving mark on the CRT. It is the information.

Vertical section controls up-down movement of the trace. (The test input goes into the vertical section.)

These 2 terminals MUST be connected together!

Beam adjustments (4) center the trace and make it clear.

Sweep section controls the horizontal speed of the trace.

Horizontal section controls the back and forth movement of the trace.

Self Quiz

1. The trace of the oscilloscope is found on the face of the _____.

2. The sweep section controls the _____ _____ of the trace.

3. The vertical section controls the _____ and _____ movement of the trace.

4. The beam adjustments control the clearness and the _____ of the trace.

5. The horizontal section controls the _____ and _____ movement of the trace.

INSTRUCTOR CHECK △
Points: ( )

EXPLORATION SHEET #____ SET UP OF THE EICO 460 OSCILLOSCOPE NAME_____

Learning Activities

You will set up a 460 EICO oscilloscope to show a sine wave.

Check out an EICO #460 oscilloscope.

Follow these directions EXACTLY in the sequence below. The names of the controls are below each knob on the scope.

1. Plug in the scope.
2. Turn the scope on. Use the center bottom switch.
3. Turn the Horizontal Selector to EXT (full clockwise).
4. Turn the Vertical Attenuator to 1000 on the DC side.
5. Turn the Intensity full clockwise.
6. Turn V Pos and H Pos to center the spot in the middle of the screen. —
7. Turn Focus and Intensity to get a very small centered spot. —
8. Turn the Horizontal Selector to the - position.
9. Turn the Horizontal Gain to make a 2" long horizontal line. ———
10. Turn the Sweep Selector to the 10 position. (Not the 10 K)
11. Turn the Vertical Attenuator to the CAL position.
12. Turn the Vertical Gain control to make the trace 2" high.
13. Turn the Sweep Vernier to produce the display shown below. Turn it very slowly!

14. Try to 'lock in' the trace. Stop it from drifting by readjusting the Sweep Vernier.

INSTRUCTOR CHECK

Have the instructor mix up the adjustments. Can you do it without the directions?

INSTRUCTOR CHECK

Total points this section: ( )

154

155

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

TESTING TRANSISTORS

NAME_____

PERIOD_____

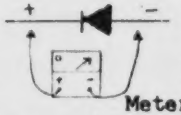
Exploring Concepts

In the Exploring Sheet on diodes you learned to test a diode using an ohmmeter. Remember, a diode only lets current flow through itself in one direction. A transistor can be tested the same way. It is often illustrated as two diodes connected together.

When checking diodes or transistors it is important to know that the positive meter probe is connected to the positive side of the battery inside the ohmmeter, and the common (-) probe is connected to the negative side of the battery.

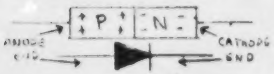
Diode conducts when the cathode is — and anode is +. This is forward bias.

Meter reads low resistance.



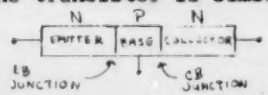
Diode stops conducting when cathode is + and anode is —. This is reverse bias.

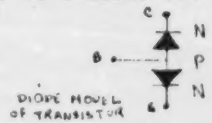
Meter reads high resistance.

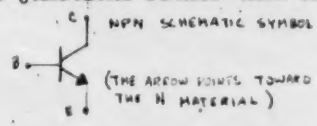


A diode is a one junction device made by sandwiching a layer of P material (positive holes) to a layer of N material (electrons).

The transistor is similar to a diode but has two junctions rather than one.



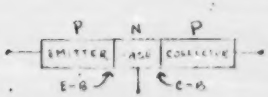


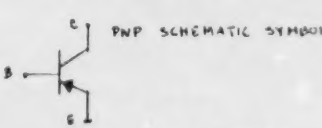


E= EMITTER

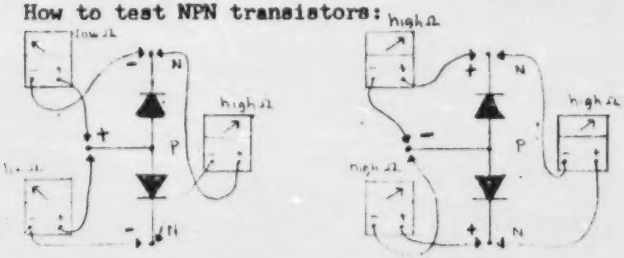
B= BASE

C= COLLECTOR

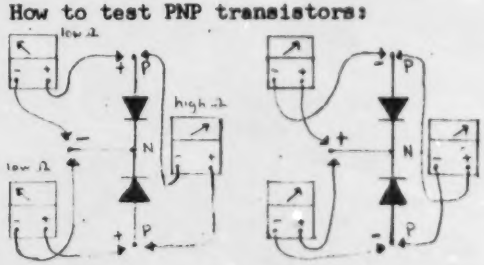




How to test NPN transistors:



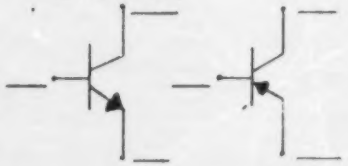
How to test PNP transistors:



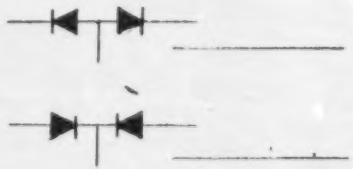
1. A zero reading means a transistor is shorted.
2. An infinite reading means a transistor is open.

Self Quiz

1. Label the correct leads and types for these transistors.



2. What type of transistor do these diode models represent?



3. Name these transistor leads:

E = _____

B = _____

C = _____

INSTRUCTOR CHECK

Points:

EXPLORATION SHEET #____ TESTING TRANSISTORS NAME_____

Learning Activities

You will test NPN and PNP transistors.

The parts kit should include:

1. VTVM
2. NPN transistor
3. PNP transistor

Set your VTVM on ohms and R x 1000 range. NPN

Figure A

1. Connect the + VTVM lead to the transistor base.
2. Take the – lead and touch the emitter. ____ Ω
3. Take the – lead and touch the collector. ____ Ω

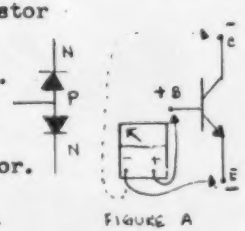


FIGURE A

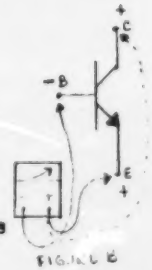
If the transistor is good, these two readings should be low (2-6 KΩ).

4. Now measure the resistance across C – and E +. ____ Ω

This reading should be high resistance.

Figure B

5. Connect the – lead to the base.
6. Take the + lead and touch the emitter. ____ Ω
7. Take the + lead and touch the collector. ____ Ω

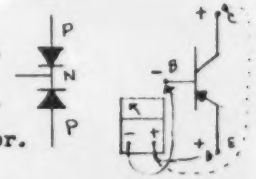


If the transistor is good the resistance readings in 6 and 7 should read high.

Keep your VTVM set on ohms and R x 1000 range. PNP

Figure C

1. Connect the – VTVM lead to the transistor base.
2. Take the + lead and touch the emitter. ____ Ω
3. Take the + lead and touch the collector. ____ Ω



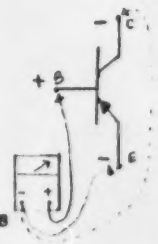
If the transistor is good these two readings should be low (2-6 K).

4. Now measure the resistance across C – and E +. ____ Ω

This reading should be high resistance.

Figure D

5. Connect the + lead to the base.
6. Take the - lead and touch the emitter. ____ Ω
7. Take the - lead and touch the collector. ____ Ω



If the transistor is good the resistance readings in 6 and 7 should read high.

If any of these readings are zero ohms the transistor is shorted.
Infinite resistance readings mean you have an open transistor.
Resistance readings across collector and base should always be high.

Self Quiz- - - - - -
Learning Activity- -
TOTAL POINTS - - - -

EXPLORATION SHEET #____

LOGIC GATES

NAME_____

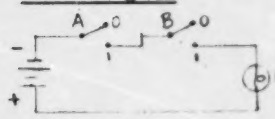
PERIOD_____

Exploring Concepts

In this Exploration Sheet you will work with some of the basic gates used in digital logic circuits. A gate is a logic circuit with one output and two or more inputs.

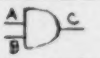
There are 5 basic gates. We will study 3: the AND, OR and NOT (Inverter) gates.

The AND gate



Light C will be on (1) only if both switches are in the logic (1) position.

Logic (1) is shown by a closed switch.
Logic (0) is shown by an open switch.



AND gate symbol

C = A x B

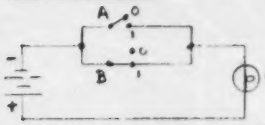
An example of the AND circuit would be a car ignition set up so the engine cannot be started unless the driver's front door is closed, front seat belts latched, and the ignition key is on. Then the car can start.

truth table

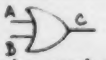
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

1. With both switches A and B open (0) the output is open (0)
2. With switch A open (0) and switch B closed (1) the output is open (0)
3. With switch A closed (1) and switch B open (0) the output is open (0)
4. With both switches A and B closed (1) the output is closed (1) and the light will come on.

The OR gate



Light C will be turned on (1) if either switch A or B is in the logic (1) position.



OR gate symbol

C = A + B

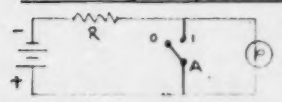
An example of the OR circuit is a home burgler alarm system that will sound a bell if any of these things happen: front or back doors open, any window opens, garage door opens.

truth table

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

1. With both switches A and B open (0) the output is (0)
2. With switch A open (0) and B closed (1) the output is (1)
3. With switch A closed (1) and B open (0) the output is (1)
4. With both switches A and B closed (1) the output is (1)

The NOT gate (Inverter)



This is the simplest form of digital logic circuit. The inverter output is always opposite of its input state.

NOT gate symbol

○ means inverted output

$\bar{A}$ bar means compliment of A or opposite.

This circuit is used to change the outputs of AND and OR gates to the opposite of their normal outputs.

An inverted AND gate is called a NAND gate.

An inverted OR gate is called a NOR gate.

truth table

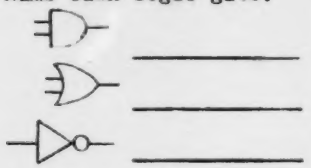
A	B
0	1
1	0

1. With switch A open (0) the light comes on (1)
2. With switch A closed (1) the light goes off (0)

EXPLORATION SHEET #____ LOGIC GATES NAME_____

Learning Activities

1. Name each logic gate.



_____

_____

_____

2. Complete the truth tables. Use '0' for open and '1' for closed.

AND

A	B	C

OR

A	B	C

NOT (Inverter)

A	B

3. Circle the correct answer.

Will the lamp be ON or OFF in this circuit?

INST. CHECK

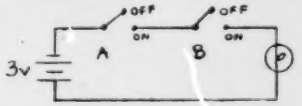
Points:

You will build and work with AND and OR circuits.

The parts kit should include:

1. 2 DPDT switches
2. 2 D 'ls
3. lamp
4. hook up wire

1. Build this circuit



Truth Table

Input Conditions		Output
Switch A	Switch B	Lamp
OFF	OFF	
OFF	ON	
ON	OFF	
ON	ON	

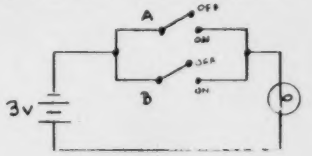
2. Complete the truth table using switches A and B.

Write ON or OFF in the Lamp Output column.

What type of logic function is this circuit performing? _____

3. Disconnect the above circuit.

4. Connect this circuit



Truth Table

Input Conditions		Output
Switch A	Switch B	Lamp
OFF	OFF	
OFF	ON	
ON	OFF	
ON	ON	

5. Complete the truth table using switches A and B.

Write ON or OFF in the Lamp Output cloumn.

What type of logic function is this circuit performing? _____

INSTRUCTOR CHECK

Total points this section:

PROJECT: TV JAMMER

If you like to have some fun you'll enjoy this project. With some patience and careful construction, you will make a device that will knock out TV and FM radio reception from up to 30 feet away.

STAGE I: CHECKING AND IDENTIFYING THE COMPONENTS

RESISTORS

	check off	Value	Fill in correct color code for each resistor		
one		R_1 10 KΩ			
one		R_2 4.7 KΩ			
one		R_3 1 KΩ			

CAPACITORS

	check off	Value	Draw Pictorial	Schematic Symbol	Identify the Type
one		C_1 .001 μfd (may be marked 102Z or other marking)			
one		C_2 5 to 80 pfd variable capacitor			
one		C_3 10 pfd			

TRANSISTORS

	check off	Type	Draw Pictorial Show EBC Leads	Schematic Symbol	Type of Transistor Outline
one		Q_1 NPN 2N3904 or Equiv.			

INDUCTORS

	check off	Type	Draw Pictorial	Schematic Symbol	Type
two		L_1, L_2 Air Core Coils			

SWITCHES

	check off	Part	Draw Pictorial	Schematic Symbol	Type
one		SPST			

E-13-2

HARDWARE

	check off	Items
one		9v battery snap
one		plastic box 2 3/4 x 3 3/4
two		machine screws 2-56 x ½"
two		machine screw nuts 2-56
two		machine screws 4-40 x 5/8
two		machine screw nuts 4-40
one		silk screened printed circuit board

STAGE II: PRINTED CIRCUIT BOARD PREPERATION

____ 1. Etch the board following the method your instructor has set up.

____ 2. Drill the component holes using a 3/64 " drill. Follow the shop model for the location of the holes.

____ 3. Clean your board with steel wool.

INSTRUCTOR OK ☐

STAGE III: MOUNTING AND SOLDERING THE COMPONENTS

Refer to the pictorial diagram for information on all of these steps.

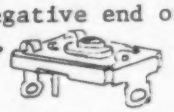
____ 1. Bend the leads of R_1 (10 KΩ) and insert it in the proper holes. Solder it in place.

____ 2. Repeat the process described above for R_2 (4.7 KΩ), R_3 (1 KΩ).

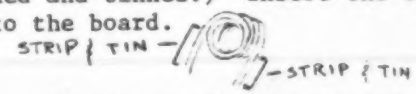
____ 3. Bend the leads of C_1 (.001) and insert it in the holes. Solder it in place.

____ 4. Bend the leads of C_3 (10 pfd), insert it in the holes and solder it in place.

____ 5. Mount C_2 (5-80 pfd) variable capacitor. Be sure the negative end of the capacitor is connected to the collector of Q_1. Look at the shop model for an example.



____ 6. Strip ALL the enamel off of the ends of the leads of the coils L_1 and L_2. Tin the ends of the leads. (The coils will not work if they are not properly cleaned and tinned.) Insert the coils in the holes and push them all the way to the board.



____ 7. Cut two 4" pieces of #22 stranded wire and strip 1/8 " of insulation off the ends. Solder one end of each wire to the switch. If your switch has 3 terminals on the bottom, use the center terminal and one of the other two. Insert the other ends of the wires into the circuit board and solder them in place.

B-13-C.

____ 8. Cut a 4'-6' piece of #22 stranded wire for an antenna. Strip one end of the wire. Solder it to the circuit board.

____ 9. Solder the 9v battery connector in place on the circuit board.

____10. Now you are ready to test the circuit. Attatch a 9v battery to the battery snap.

Turn on your TV to channel 2 or 6 and start adjusting the screw on the variable capacitor with a small screwdriver. Slowly turn the adjusting screw until you hear or see a disturbance in the television. With careful adjustment you will completely blank out reception.

If everything is working OK you can also blank out FM radio reception.

____11. If your TV jammer doesn't work, go back and thouroughly check all solder connections and the placement of all components. Compare your project with the shop model.

MORE STATION ALIGNMENT HINTS

TV channel 6 is easiest to disrupt.

If stations 6 or 2 are not disrupted, push the turns of the coils closer together.

If stations 8, 10, or 12 are not disrupted, use a small screwdriver to spread out each turn in both coils.

Remember, each TV or radio station requires a different setting of the variable capacitor.

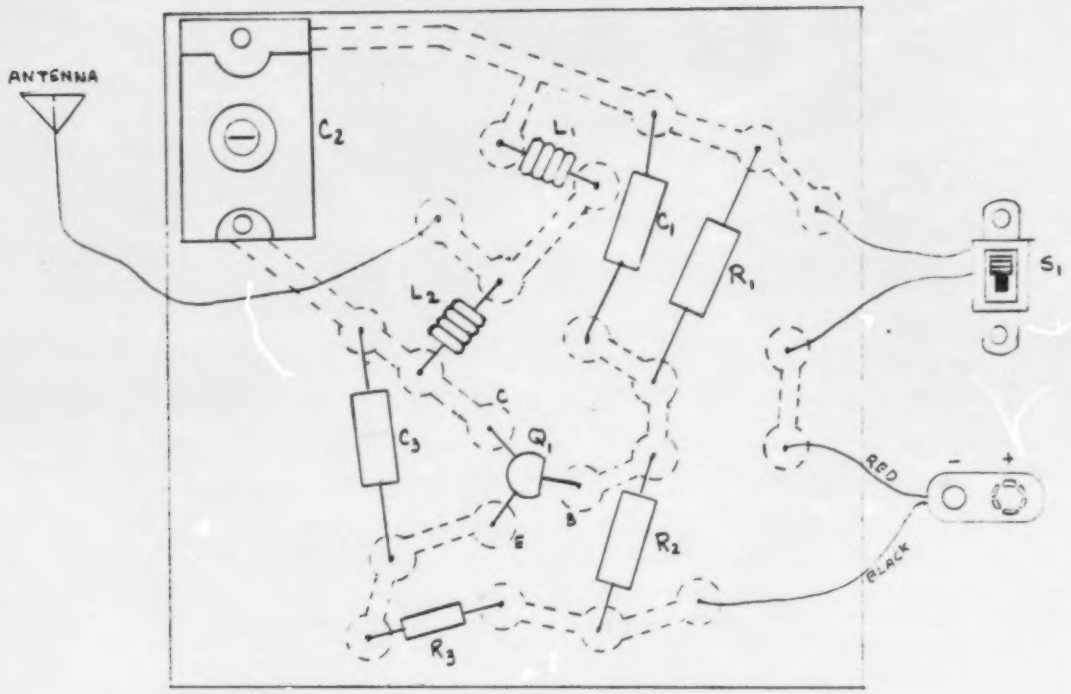
OTHER USES

To use this circuit as an FM transmitter, connect a carbon microphone in series with the 9v battery. Then adjust the tuning knob on the radio and the C_2 on the jammer until the station on the radio is blocked out. (Use C_2 for coarse adjustment and the tuning knob for fine adjustment.) Then speak through the microphone and hear yourself on the radio!

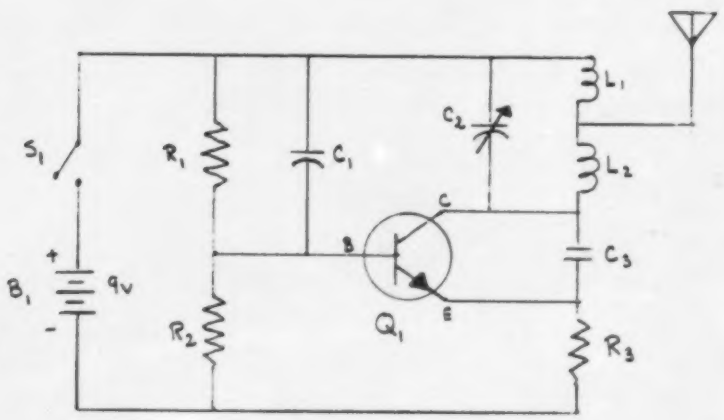
It can also be used as a BUG!

. . . Try your own experimenting . . .

12-13-a



Component Side View
Pictorial



Schematic

8-13-d.

Safety Note

The materials in this guide are a collection of projects which have been used in electronics programs for years. Some projects have been published in electronics magazines, and others are examples of products from electronics kit companies. It is unfortunate that so little information is given pertaining to safety with line-operated projects. In a class, onlookers often think is a joke when someone gets a shock. Under some conditions a small shock from small inductors under low power may not be harmful, but coming in contact with the power line must be guarded against. As you know, under certain conditions electrical shock can be lethal. In the school shop the conditions can be controlled, but what about the home? The students that thak their projects home to work on them may not have the same safe conditions in their basement "labs".

Some of the projects contained in this guide are line-operated and, because of this, should be undertaken with special care. ALL LINE-CONNECTED PROJECTS should be tested with the use of an ISOLATION TRANSFORMER and under your DIRECT supervision. BEFORE any line-operated project can be taken home, it must be housed in an enclosure which will protect the circuit and will not present a shock hazard. The student needs instruction for safe practices with this project. The student must RECOGNIZE what a hazardous condition is.

The author believes that there is value in working with line voltages, but the personnel must be qualified. Qualification comes from good instruction and practice. It is your responsibility to give the student not only the skills to work but the skills to stay alive and unharmed.

Purpose of "Hands On" Projects

The purpose in using projects as part of the training procedure is outlined in the following set of objectives:

By completing prbjects the students will obtain the following:

1. An exposure to the real electronic components in the product form.
2. An awareness of the "state of the art."
3. The construction of the student's own project.
4. A feeling of control and accomplishment.
5. A direct application of electronic theory and practice.
6. Practice in handling tools and materials.
7. The ability to successfully follow circuit plans and drawings.
8. The ability to fit parts together in a professional manner.
9. The ability to work at a speed that will produce quality products.
10. The ability to work safely with power tools and live electrical circuits.
11. The ability to work individually or on a team project.

The accomplishment ot the above objectives depends on your skill to prepare and organize materials and students.

With the beginning student, it is always best to start with a project that is easy for the student to handle. The first attempt by the student must be a successful experience. For this reason, selection of the first project is of prime importance. You cannot tell the student "Here, go and do this." You must sell the project to the student with the enthusiasm of the best salesman. The student's own experience with the project must verify what you have told him or her about it. The student must feel that the project has worth and that he or she has the ablilty to do it. The feeling of self-worth and accomplishment for the student is of maximum importance. You should have samples of projects, in mint condition and working, for the student to see and try out. Remember that the sample must be a work of art. As the student is working his or her way through the project, always work with him or her in positive terms. NEVER use negative terms. unless you can sense that the student wants to hear it. As an exsmple, say: "This is good work. Do you think that there is any way that the quality could be improved?" Normally the student answers by pointing out what must be done.

BIBLIOGRAPHY OF REFERENCE TEXTS

Fowler, Richard J., Electricity, Principles and Applications, McGraw-Hill Book Company, 1979.

Grob, Bernard, Basic Electronics, New York: McGraw-Hill Book Company, 1977.

Schuler, Charles A., Electronics, Principles and Applications, California, Pennsylvania: McGraw-Hill Book Company, 1979.

Steinberg, William and Walter B. Ford, Electricity and Electronics Basic (fourth edition), Chicago, Illinois: American Technical Society, 1972.

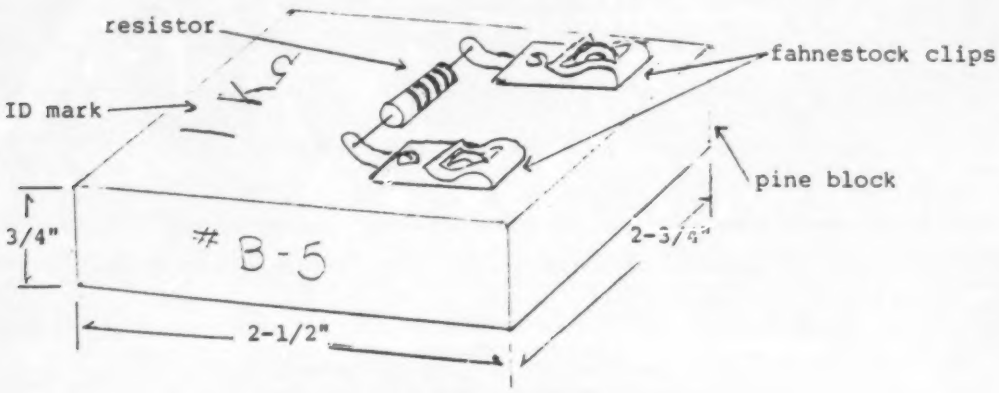
Secretary, National Electrical Code Committee, (National Fire Protection Association Electrical Field Specialist), National Electrical Code, New York: McGraw-Hill Book Company, 1981.

Exploration Sheet Circuit Trainer

for Levels 1-2

A successful experience for the student is a characteristic of a quality teaching system. To provide this type of environment for middle school lab work will require special planning and materials. The Instructional Planning concept sheets and Exploration Sheets provide a well organized study plan and worksheet system for the student. To complete the student's 'hands on' experiences, a circuit trainer should be used for the lab work.

The circuit trainer design as outlined in the following description can be constructed in the shop using standard parts. This will make the units easier to service and also reduce cost. Electronic parts are small and sometimes easy to break. To make them easier to handle they are mounted on 3/4 inch thick pine blocks approximately 2-1/2 inches square (some blocks may have to be larger to accept some components such as power transformers, etc.) The terminals used are medium size fahnestock clips (see below):



Component Block

The connection between the component blocks can be made with hook-up wire to form the circuit.

To make the system easier to move and store, the student should use a tray or board 16 inches to 18 inches square to keep the component blocks on as he or she works.

Minimum Recommended Tool and Equipment List
for Levels I, II, & III

soldering iron 30w	12
replacement tips	12
pliers, diagonal cutters 5"	6
pliers, long nose 6"	6
wrench, vise grip 7"	2
screwdrivers, #1 phillips	6
screwdrivers, #2 phillips	6
screwdrivers, spadebit 3/16" x 8"	6
nutdriver, 3/16"	2
nutdriver, 1/4"	2
nutdriver, 5/16"	2
nutdriver, 11/32"	2
nutdriver, 3/8"	2
aviation snips, M-3	3
reamers, 1/8" to 1/2"	2
reamers, pipe 3/8" to 1-1/2"	2
pop rivet gun	2
rivets, .020 to .125 (box)	2
wire solder 60/40 MC (spool)	8
wire stripper	2
hex nuts, 6/32" (box)	10
machine screws, 6/32" x 1/2" (box)	10
sheetmetal screws, 3/8" x 4" (box)	10
sheetmetal screws, 3/8" x 6" (box)	10
drill bit, 3/64" diameter	25
drill bit, 3/32" diameter	5
drill bit, 7/64"	5
drill bit, 9/64"	10
drill bit, 1/4"	5
drill bit, 5/16"	5
drill bit, 3/8"	5
solder lugs, 6/32" diameter hole (ea)	1000
test lead wire, red (feet)	200
test lead wire, black (feet)	200

alligator clips, red (ea)	100
alligator clips, black (ea)	100
banana plugs, red (ea)	100
banana plugs, black (ea)	100
batteries, 1.5v dry (ea)	12
bell, electric	6
buzzer, electric	6
push button	6
washers, shakeproof #6 (box)	10
allen wrench set	3
headsets, 2000 Ω	6
VTVM meters, electric	6
audio generators	3
oscilloscopes	3
power supplies, 0-20v	3
enamel wire, #22 (spool)	1

Glossary of Applied Terminology

Concept (electrical) - a series of related applicable theories based on basic electrical laws.

Levels (instructional) - a group of related concepts that are used to make a learning sequence that is keyed to fit the student's ability and knowledge to provide advancement to the next instructional level.

Depth of Instruction - the complexity of instruction that the instructor uses in planning and presenting class activities.

Level sequence - a step-by-step progressive set of courses organized in a simple to complex development to elect5ical skills.

Activities - the class time activities consisting of:

classroom lectures, demonstrations, and assignments in texts and learning materials

laboratory work with experiments and projects

Evaluation - the student's performance will be evaluated by:

written examination

oral examination

work sheets

obscrvation of manipulative skills

operation of test equipment

oral and written explainations of project and experiment function

visual appearance of workmanship

effective participation in class and lab activities

ability to work with others

WORK EXPERIENCE RECORD

Dates	Jobs Performed	Evaluation

PLACEMENT RECORD

Date	Firm, Address and Contact	Contacted	Inter-viewed	Result

Student _____

School _____

Instructors _____

Telephone _____

Program	
1 yr	
2 yr	
3 yr	

The skill level indicated on this card is a reflection of the student's ability at the time of evaluation. Skill level retention will depend on the amount of time elapsed since evaluation and amount of continued exposure to activities in the stated skill area.

	The student can accomplish this skill:
levels	
9 - 10	With excellent success at levels equal to, or higher than program standard without supervision. (Shows initiative, adaptability and leads others.
7 - 8	Without supervision, with proficiency in speed and quality.
5 - 6	Satisfactorily, but requires periodic supervision and or assistance.
3 - 4	Satisfactorily, but may require repeated orientation.
1 - 2	With additional training and supervision.
NA	No exposure in this area.

SAFETY

	NA	1	2	3	4	5	6	7	8	9	10
a. Uses equipment properly											
b. Uses safety devices											
c. Uses personal protection											
d. Recognizes hazardous conditions											

TECHNICAL COMMUNICATION

	NA	1	2	3	4	5	6	7	8	9	10
a. Reads and follows schematics											
b. Writes service reports											
c. Can look up service data											
d. Has keyboard skills for typing and computer use											

ELECTRICITY/ELECTRONICS
VOCATIONAL SKILLS RECORD

(DRAFT)

APPLIED MATHEMATICS & COMPUTER

a. Uses basic arithmetic functions
b. Uses basic algebraic and trigonometric functions
c. Uses basic computer numbering systems
d. Uses computer language skills, BASIC
e. Uses computer language skills, FORTRAN
f. Uses computer language skills, PASCAL
g. Uses calculus

NA	1	2	3	4	5	6	7	8	9	10

MAINTENANCE OF TOOLS AND EQUIPMENT

a. Identifies and uses basic hand tools
b. Identifies and uses basic power tools
c. Maintains hand and power tools for proper operation

NA	1	2	3	4	5	6	7	8	9	10

TESTING AND TROUBLESHOOTING

a. Can select correct test equipment
b. Can do basic circuit analysis
c. Maintenance of test equipment
d. Operates test equipment
e. DC systems - power
f. AC power distribution systems
g. Audio systems
h. RF systems
i. Digital systems

NA	1	2	3	4	5	6	7	8	9	10

ASSEMBLY AND REPAIR OF ELECTROMECHANICAL EQUIPMENT

a. Identifies mechanical and electrical components
b. Assembles mechanical systems
c. Assembles electric/electronic systems
d. Solders and desolders
e. Connecting and disconnecting assemblies

NA	1	2	3	4	5	6	7	8	9	10

BASIC ELECTRIC/ELECTRONIC THEORY

a. Can apply the basic theories of DC
b. Can apply the basic theories of AC
c. Can describe the basic operation of: Power supplies
d. Amplifiers
e. Oscillators
f. RF communication circuits
g. Op amps
h. Digital fundamentals
i. Microprocessor applications

NA	1	2	3	4	5	6	7	8	9	10

HUMAN RELATIONS

a. Trustworthy
b. Self-initiative
c. Self-reliance
d. Punctuality and attendance
e. Personal appearance
f. Leadership and assertiveness
g. Attitude
h. Respects the rights of others
i. Able to work with others

NA	1	2	3	4	5	6	7	8	9	10

OTHER EXPERIENCE AND COMMENTS

BEST COPY AVAILABLE